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SCIENTIFIC MAN-POWER IN BRITAIN AND ITS UTILIZATION

THE eighth annual report of the Advisory Council on Scientific Policy, covering the year April 1954–March 1955 (Cmd. 9537. London: H.M.S.O. 6*d*. net) does not, like the previous report, range over the whole field of the Council's work. It discusses five topics; but with the exception of one, the Institute of Seaweed Research, they are all interrelated, and essentially the report is a statement of the Council's views on the nation's resources and the deployment of scientific man-power, to which theme the whole of its fifth report was devoted. Indeed, the Council's inquiry as to whether further research work on seaweed should be encouraged at the Institute of Seaweed Research, and if not, what use could be made of the staff and facilities of the Institute, has also clearly been dominated by considerations of the present shortage of skilled research workers in Britain. This particular inquiry was undertaken at the request of the Development Commission, and the Biology Committee of the Council, while satisfied as to the value of the results obtained and the competence with which the work had been carried out, recommended that experimental work on the mechanical harvesting and drying of seaweed should be terminated, and other arrangements made for the continuation of research on algal chemistry. Research has already advanced far enough to permit reasonably rapid exploitation of seaweed if need arises, but earlier hopes that alginates would serve as a technically and economically desirable source of chemicals have been disappointed. The Committee could suggest no other major subject of research for which the Institute, as constituted, seemed specially suited, and in endorsing these conclusions the Council observes that an Institute with a wider field of interest, or one which forms part of a large research organization, is better adapted to divert its effort into fresh channels when experience indicates that this is desirable.

This comment is sound enough as applied to institutions mainly supported by the State, at least in present circumstances, and it emphasizes the importance of the continuing and periodical review of the work and functions of existing research institutions in relation to national needs. But it also emphasizes the importance of the independent research institution, which can afford to explore lines of investigation not sufficiently promising to justify State support. Again and again such independent bodies have proved the growing points of scientific achievement, and the corollary of any tightening of central control of the work of the State's own research institutions should be a generous and enlightened attitude to the independent institutions able to cover the gaps.

Thus this minor and particular inquiry points to the same need for an imaginative and enterprising direction at the centre, in order that the man-power resources of Britain may be wisely and most efficiently deployed, as does the Advisory Council's examination of the further problems of science teachers and scientific man-power, recruitment to the engineering industry, Colonial research and scientific libraries. On the second topic, its comment is indeed reserved. An inquiry conducted by the Council's Scientific Man-Power Committee revealed considerable differences of opinion within the engineering industry both as to the effect of university expansion on the recruitment of apprentices and as to the value to industry of certain forms of postgraduate work in engineering at the universities. The Council is examining in further detail the issues involved and hopes to report on them later in the year.

Meanwhile, it is sufficient to note that the Advisory Council has already emphasized the important bearing of these matter on educational policy, with which the question of the shortage of science teachers is as closely related as it is with the scientific man-power situation. On that subject the Council's analysis is not, of course, so deep as that of Sir Edward Appleton's committee, although the latter was concerned only with the supply of teachers of science and mathematics in Scotland. The Advisory Council's review, however, is set in a wider context and in itself demonstrates the futility of attempting to deal with problems on departmental lines. The issues and implications are too serious for the shaping of educational policy and scientific policy to be scattered over unrelated departments without a far more determined and imaginative effort at Cabinet level to devise a policy consistent with national needs than has yet been apparent.

The Advisory Council appears to be aware of this, though it might have expressed the matter more forcefully. It recognizes the danger arising if the number of students now graduating in science and mathematics, though more than twice that in 1939, continues to fall short of the current demand for scientists, still less to keep pace with the steady increase in demand. The scale of the scientific effort of Britain, which depends on the numbers and quality of the trained scientists and technologists available, conditions both the effectiveness of the national economy and the security of our defence. Nor can the universities and the colleges of technology play their part unless there is an adequate flow to them of boys and girls who have been introduced to science by teachers capable of revealing its attractions and interests and the careers to which it may lead.

Hence follows the seriousness of the decline in quality of newly recruited science teachers since the War, and of the threatened more serious shortage unless the rate of recruitment rises as the secondary school population increases and as more boys and

girls remain at school until the age of university entrance. The latest information which has reached the Advisory Council suggests that the number of graduate science teachers in the schools has risen appreciably during the past two years. Figures quoted for England and Wales show an increase from 14,419 in 1952 to 15,335 in 1954; for maintained grammar schools, the corresponding figures are 7,659 and 7,910, the increases being fairly equal in each year in both cases.

The Advisory Council, while welcoming the acceptance by the Government of the recent proposals of the Burnham Committee, which would give increases of up to £200 per annum for senior masters, does not commit itself as to the adequacy of the proposals, beyond observing that their effect on the recruitment of science teachers should be carefully watched. The Council considers salaries to be of great importance, though this factor has its limits, and will scarcely influence either those with a definite vocation for teaching or those unprepared to consider teaching in any circumstances. Nor is its effect on others likely to be so great as that of the teacher himself on a pupil considering a career, or a widespread and imaginatively conducted campaign to influence public opinion.

For like reasons, deferment of National Service is likely to have but a limited effect in increasing the number of science graduates who take up teaching. The Advisory Council supports the recommendation of the Appleton Committee and of that appointed by the Federation of British Industries, and the Minister of Labour has since announced, on July 28, the indefinite deferment of first-class or second-class honours graduates in science and mathematics who take up teaching in a school maintained or aided by public funds. This is estimated as likely to give a further fifty or more science teachers a year, and is to be welcomed for that reason and as impressing on the country the serious national importance of the problem. It is unlikely, however, to influence many to take up teaching as a career; science graduates already have many other opportunities of finding work the national importance of which carries exemption from National Service in the military sense.

The argument for deferment derives its strength from the lessened risk of waste of man-power that it at least implies, and while the Advisory Council rightly gives no countenance to the suggestion from the Ministry of Education that over the next few years government departments and industry could reduce their recruitment of science graduates so as to increase the size of the pool from which the schools draw their science teachers, it recognizes the importance of seeing that the services of science graduates are fully and appropriately used. The suggestion runs counter, at least in the short-term, to current trends and accepted policy; for example, to the expansion of postgraduate scientific and technological education. The Advisory Council leaves industry to speak for itself in the matter, merely remarking that in general the industries of Britain are under-manned scientifically and that if industry temporarily relaxed its pressure for trained scientists it should do so only in the interests of the scientific man-power problem as a whole, and on the understanding that to do so would assure a greater supply of scientists in the future.

So far as official bodies are concerned, the Advisory Council sees little possibility of any reduction in the recruitment of science graduates. It puts the number of science graduates employed in government and allied research establishments (including the Atomic Energy Authority, the research councils, the research associations of the Department of Scientific and Industrial Research and the Service Departments, but excluding Service personnel) as less than 10,000. This is about half the number of graduate teachers of science (including teachers at technical colleges, and in Scottish schools, but excluding independent schools and the universities). The expansion of government scientific staffs has for some time been strictly limited, and established posts are mostly only just sufficient to meet the responsibilities of the departments and research organizations concerned. The Armed Forces may be an exception, and the Council recommends that their requirements of first- and second-class honours graduates for certain posts in the Active Forces should be reviewed to see whether the qualifications demanded are justified.

That recommendation could well be more widely applied, and to a point at which it impinges even more directly on educational policy. While in both government departments and in industry public policy would benefit by the wider use of men and women with scientific training and outlook in administrative positions, that should neither imply not exclude possession of a degree in science. Some economy in the use of science graduates might be secured by the use of graduates in arts, for example, in posts where no special scientific knowledge is required. This would be increasingly possible if educational policy ensured that in this modern age every university graduate acquired some understanding of the method and achievements of science.

The corollary of such recommendations, however, is a fuller inquiry into the man-power situation. The Advisory Council makes no reference to the implications, for that situation, of the development of nuclear energy, of the Government's programmes for the development of rail and road transport, or of the deficiencies of some of the nationalized industries in regard to research and the use of trained scientists and technologists. The figures quoted need to be set in the context of the present figures for industry, including the nationalized industries as a whole, having in mind the under-manning to which the Council refers, and in the light of the intake which would be required to maintain the employment of scientists and technologists even at its present level.

The Advisory Council also considered a suggestion that the pool from which science teachers are drawn might, as a short-term measure, be increased by reducing the number of science graduates who are

accepted for university postgraduate courses. Academic leaders have in fact on other grounds questioned the desirability of accepting as postgraduate research students those who do not show clear promise of ability as research workers, and of making postgraduate research the exception rather than the normal rule for an honours graduate. The Advisory Council estimates that out of 5,500 first-degree graduates in pure science (including some 500 overseas students), about 1,500 men are deferred annually from military service for further university study, of whom some 250 are registered for teachers' training courses. More than half these appear to be working for a higher degree, and about one in three of first-degree science students stay on at the university for an additional two or three years. Of these, some 500 possess awards from a research council granted under a very rigorous system of selection, and the Ministry of Education works to similar standards in considering applications for the extension of State scholarships. It is not certain, however, that the same standards are invariably applied to students who are supported by other sources. The Advisory Council suggests that if the universities are not applying over the whole field of graduate science training the rigorous standards which now govern the postgraduate awards of the research councils and the Ministry of Education, they should be asked to consider doing so. The Council has already asked the University Grants Committee to collect information as to the academic standards of those holding postgraduate awards in science.

This is a sound suggestion. It will not, nor is it intended to, reduce the volume of worth-while postgraduate research; though it may well eliminate some of the more futile essays in that field. Nor will it make available to the schools the best of the science graduates, or even increase the immediate supply of graduates, since those no longer deferred as research students would be liable for immediate National Service. Their National Service over, however, they would be seeking posts when the shortage of science teachers is expected to be even more acute, and some at least might become teachers.

This, like most other measures suggested by the Advisory Council, is a short-term measure. As long-term measures the Council looks to an increase in those reading science at the universities sufficient to meet the needs of all fields of employment, though it suggests that reduction of early specialization in the schools and encouragement at the universities of the study of science as part of a general university education would greatly help. Inquiries are already in progress, it is stated, into ways of producing non-specialist graduates with a broad training in science, who would be suitable for various posts in industry and the government service, and who would also be competent to teach science and mathematics in the schools.

There is another aspect of the man-power situation which is emphasized by the Advisory Council in this report, and that is in relation to the inadequate volume of research on Colonial problems. Further discussions with the Colonial Office have confirmed the Advisory Council in its view that the total volume of research in the Colonies is far too small. Only some 450 scientists are at present engaged in Colonial research—little more than one-tenth of the number of scientists employed in the United Kingdom by the Department of Scientific and Industrial Research and the research councils—and of these, less than a hundred are members of the Colonial Research Service. The Advisory Council recognizes that in present circumstances it is difficult to increase the number engaged in this work rapidly, but it expresses the firm opinion that everything possible should be done to increase the man-power available and ensure its better distribution. Pointedly, it expresses the hope that further developments will not be hindered by lack of adequate financial support.

That is a matter to which the Government should be giving attention, though it was not raised in the debate on the Colonial territories in the House of Lords on July 6, nor did Lord Lloyd refer to research in his reply for the Government. The Advisory Council emphasizes the urgent need for more research on long-term problems, such as population trends and food supplies, and reiterates the view as to the need for more plant geneticists and soil scientists in particular. Moreover, while the initiative for starting Colonial research projects generally rests with the Colonial territories themselves, scientific resources are likely to become even more stretched as social and political development quickens and local resources for long-term research may diminish. In this connexion, the Inter-University Council for Higher Education Overseas has pointed out that the development of the Colonial universities has transformed the position of science and scholarship within the Colonies and greatly encouraged research.

That there will thus be need for greater initiative to be taken in London in suggesting subjects for long-term research may be no bad thing, if the arrangements for concerting Colonial research policy are improved and the defects in organization which recent reports on Colonial research seem to suggest are overcome. It would fit in with the general observation which the Advisory Council makes in respect of the Seaweed Research Institute and, in view of the contribution which the Department of Scientific and Industrial Research is already making in certain fields of Colonial research, it may be hoped the committee now investigating the work of the Department will not overlook the possibilities in this respect. Sir Alexander Todd's membership of the committee, in view of his observations on this subject to the Parliamentary and Scientific Committee on July 12, certainly warrants this hope.

Meanwhile, it may be noted that the observations of the Inter-University Council fully endorse all the Advisory Council's remarks on the importance of looking on Colonial research as one special aspect of Britain's research effort and organization. The encouraging picture which the Inter-University Council depicts of expanding research stations and organizations in the Colonial territories, and of scientists in direct and continuous contact with local

problems and opportunities who are accumulating a valuable body of local experience which they are linking with the world of organized learning, should not disguise the dependence of this man-power on institutions which are themselves largely fed from Great Britain—and often directly from British institutions. Apart from the fact that it will be a long time before most of the Colonial universities develop strong postgraduate schools from among their own students, the wise deployment of British scientific resources demands that Colonial research be considered as part of the wider problem. The suggestions made by the Inter-University Council for an increasing flow to the Colonial universities of research students and academic staff on sabbatical leave to use the facilities and opportunities now available, like the Advisory Council's proposal for the creation of pools of scientists in all the main fields of Colonial research, should be considered in this context. The latter proposal in particular, which might permit a British institution to send a senior man from its own staff for a few months to start a project, leaving it to the local staff to complete, seems well calculated to secure economy of man-power for many Colonial problems.

The Advisory Council's observations on this point, and particularly its plea for further assistance to the science departments in the new Colonial universities, and for the extension of home-based pools of scientists as indicated above, have a vital bearing on economy of man-power, and also on the efficient use and administration of Colonial Development and Welfare Funds and on educational policy—including the expansion of Colonial universities and university colleges and of higher technological institutes. The same consideration of economy in man-power has determined the Advisory Council's fresh reference to the proposals for a national reference library of science and invention and a national science lending library as part of the proposed 'science centre'. Both schemes are regarded by the Advisory Council as important if not essential for the efficient use of our existing scientific and technical man-power. Both are urgent, and the Advisory Council cannot see practical alternatives to either scheme. Disregard by the Government of the Advisory Council's renewed plea for firm decisions in favour of an early start for both these national library projects as part of a policy of equipping the nation with adequate scientific and technical library facilities can only mean a complete failure to appreciate the over-riding necessity for a concerted policy in education, research and development in order that the scientific and technical resources of Britain may be wisely and fully used.

That is the outstanding impression to be derived from the eighth annual report of the Advisory Council on Scientific Policy, and it was brought out even more emphatically by Sir Alexander Todd in the address to the Parliamentary and Scientific Committee already noted. In that address Sir Alexander estimated the total number of graduate scientists and engineers in the United Kingdom as 0·9 per cent of the working population, compared with 0·5 per cent in 1939, but with United States figures of 0·9 per cent in 1939 and 1·7 per cent in 1950; and he gave the distribution of 78,000 graduates in mathematics and science in Great Britain as 12 per cent in Civil Service and allied establishments; 25 per cent as teachers in grant-aided schools and technical colleges; 3 per cent in universities; and 60 per cent, including perhaps 2·5 per cent in independent schools, otherwise employed. He also said that present shortages of scientists are most serious among physicists, chemists, metallurgists and engineers, and that the demand for graduates in the engineering industry exceeds supply by about one-third. Sir Alexander added much more to indicate the lines on which educational policy should be shaped to deal with the situation as a whole; but although his address was freely quoted in the House of Commons on July 21, and Mr. A. H. Albu in particular quoted further estimates of the need, as distinct from the demand, for qualified engineers and scientists, apart from Mr. Albu's suggestion that a comprehensive review of the situation and the action required to meet our rapidly changing needs should be the responsibility of one senior Minister, there was no hint in the debate of the importance of urgent action at a high level. Indeed, the Minister of Education, Sir David Eccles, agreed with much that Mr. Albu had said as to the shortage of scientists and technicians, and made some wise comments as to the importance of general education and a sense of values; he also promised a full statement before Christmas as to the Government's plans for shaping the educational system of Britain so as to provide an alternative and much more broader route than that leading to a university degree for providing the very large number of technicians required to support the technologists and scientists. Nevertheless, Sir David appeared to be concerned at present chiefly to defend the dubious decision to institute a new award in technology. Moreover, in declining to include in his review of technological education the work of the Royal Technical College, Glasgow, he demonstrated again the departmental limitations and piecemeal approach which have consistently marred the handling of these and related problems by the present Government as well as by its predecessor. There are indeed sound objections to a Ministry of Science; but such proposals will continue to be pressed until clear evidence is forthcoming that the significance of science and technology in the affairs of State is fully appreciated by the Government, that due weight is given to them in determining educational, economic and defence policy, and that departmental prejudices are not allowed to overrule the recommendations of the Government's scientific and technical advisers.

The Advisory Council's report at least leaves no room for doubt as to the urgency or magnitude of the present problems, or that some very considerable administrative changes are required if belated and inadequate measures are no longer to waste our limited existing resources and delay the development or creation of fresh supplies of man-power or energy.

THAT INWARD EYE

The Mind and the Eye

A Study of the Biologist's Standpoint. By Dr. Agnes Arber. Pp. xi+146. (Cambridge: At the University Press, 1954.) 16*s.* net.

THIS review should begin with an apology to the author of "The Mind and the Eye". Her book was in the reviewer's hands some months ago; but circumstances at the time made it impossible to give it the leisurely scrutiny it deserves. Perhaps this delay has its advantages, for there is now an opportunity to assess the value of the book a little at a distance, in a better perspective than is generally afforded to a reviewer.

There is something very depressing about contemporary biological journals. Paper after paper records observations or experiments, analyses them cautiously, and in a timid and tentative way compares them with previous observations and experiments on the same theme. That is about all: only rarely does the writer of a research paper disclose to the reader precisely what led him to do the work, and only rarely does the writer disclose how (in his view) his work is related to the broad panorama of biology. There are doubtless sufficient reasons for these omissions: many writers of papers undertake the research they describe for no other reason than that their supervisors have 'put them on to it', and many editors of journals consider contemplation out of place in science and do not encourage authors to indulge in it. The result is that apart from a few vigorous growing points, the proliferation of biological research appears to an observer to be formless, unco-ordinated, and to some extent superfluous or at any rate untimely.

In this perspective, Mrs. Arber's book stands out as a work of genuine scholarship and special timeliness. It ought to be prescribed reading for every fresh graduate who proposes to begin research, and it ought to be read again by every young research worker before he sends his first paper to the press. Mrs. Arber begins by a lucid description of the five familiar stages of scientific investigation: the formulation of a problem (a stage sometimes omitted), the collection of data, the interpretation of the data, the testing of the interpretation, and the communication of the results to the scientific world. She has important things to say about all these stages, and she embellishes her discussion by reference to philosophy and literature and art. How refreshing it is, for example, to hear that the choice of a subject for research involves "the art of rejection", and to be told that this art can be compared with the art of the Chinese in designing the empty spaces in their pictures. It is refreshing, too, to be reminded (and for many research students it is to be told for the first time) that the very observations one makes, and *a fortiori* one's interpretation of them, are limited by the *Zeitgeist* and by unconscious philosophical assumptions derived from Spinoza.

If only biologists would study Mrs. Arber's chapter on writing up the results of research some of the *malaise* of our research journals might be cured. Communication is an essential part of research. "There is no escape," Mrs. Arber says, "from the compulsive truths that the biologist must write, that writing is an art, and, moreover, a highly symbolic art." It would be well if these words were frequently quoted in universities, for we are still in the state of mind that we willingly spend a year perfecting a technique, but we are unwilling to spend a week writing the paragraph describing the technique; and so the accuracy of experimentation may be blurred by clumsy communication. In this excellent chapter Mrs. Arber falters (in the reviewer's opinion) only twice: once when she implies that the quality of writing in research papers can be too good, because sensitive idiomatic English is harder to translate into foreign languages than poor writing is; and once when she confuses lucidity with over-simplification, and goes on to make the dubious assertion that the opaque passages in a piece of writing "keep the reader awake". These seem poor excuses for taking the edge off the precision of one's instrument. Cyclotrons and electron microscopes notwithstanding, language remains the chief instrument of the scientist.

Having dealt elegantly and convincingly with these five stages of scientific investigation, Mrs. Arber comes to the main theme of her book, namely, that there is a sixth stage: contemplation, meditation, reflexion on the methods and assumptions and implications of scientific research. With a wealth of reading and contemplation behind her, Mrs. Arber discusses the concept of truth in biology (the subtle difference between *Richtigkeit* and *Wahrheit*); she admits that a biologist cannot be an expert on his philosophical assumptions or on his microscope, but she asserts that he ought to have given thought to both these instruments; she doubts (and the reviewer would join issue with her here) whether Occam's razor is as efficacious in biology as in the physical sciences; and she has very sensible things to say about antitheses in biology: matter and form, form and function, mechanism and teleology. Her last antithesis is the mind and the eye. Is one to agree with Coleridge, who thought it necessary "to emancipate the mind from the despotism of the eye" as a condition of abstract thought? Or does the eye provide the yarn out of which the mind weaves abstract thought? Mrs. Arber subscribes to the view that mental activity and sense impressions are inseparable and that the eye is junior partner to the mind.

This book is an example of scientific criticism worthy to stand beside the best literary criticism of our time. Is it too much to hope that working biologists will take it seriously? If they do, we might expect a notable improvement in the quality of scientific writing.

ERIC ASHBY

LINEARIZED AERODYNAMICS

Linearized Theory of Steady High-Speed Flow

By Prof. G. N. Ward. (Cambridge Monographs on Mechanics and Applied Mathematics.) Pp. xv+243. (Cambridge: At the University Press, 1955.) 30*s.* net.

FOR some years, research workers in theoretical aerodynamics have been greatly indebted to Prof. G. N. Ward for the fine series of papers in which he has made a number of fundamental and important contributions to the linearized theory of steady high-speed flow, and they will welcome the appearance of this volume in which the author's researches are expounded in magisterial fashion. The volume is, in fact, a revised and shortened version of an essay submitted in competition for the Adams Prize in the University of Cambridge. Its pub-

lication in a certain sense marks the end of an epoch, for the linearized theory has reached the stage of completion, in the sense that it is now possible to formulate and to solve almost all the problems which can be usefully tackled by means of this theory. Further advances inevitably and reluctantly will almost certainly be made by means of non-linear theories.

It is well known that the essence of the linearized theory consists in retaining only those terms which are of the first degree in the disturbance velocities, the pressure excess and the density variation which are produced by the passage of an aircraft or a missile through still air. The enormous advantage of the linearized theory is that it is possible to bring to bear all the methods of classical mathematical physics and, in particular, the powerful methods of potential theory and of wave theory. What makes the subject particularly exciting is that in the supersonic range all the concepts and methods of classical potential theory need considerable revision, and that progress is scarcely possible without employing some mathematical methods equivalent to Hadamard's theory of the finite part of divergent integrals. The use of Heaviside transforms and Fourier integrals can also be employed with great effect. The present volume gives a complete and self-contained account of all the mathematical techniques which are required in the solution of linearized equations and, in particular, of the important integral identities discovered by the author in collaboration with F. Ursell.

After an introductory chapter which carefully analyses all the assumptions involved in the linearization of the equations of motion, the author proceeds to discuss in the two following chapters the general solution of these equations for subsonic flow and for supersonic flow. He then gives a number of corollaries related to the boundary conditions, aerodynamic forces, uniqueness of solution and the interesting flow reversal theories.

The second part of this work is concerned with a number of special methods. First, the subsonic flow past thin bodies is discussed with special reference to the developments of the Prandtl–Glauert rule.

Then the author discusses supersonic flow past nearly plane wings. Here the pioneer work of Evvard is extended so that these problems are reduced to the solution of a number of integral equations of Abel's type. This is followed by a study of conical fields in supersonic flow which follows admirably the exposition given by the author and Prof. S. Goldstein. A whole chapter is then devoted to the application of operational methods, with special reference to the flow past quasi-cylindrical ducts and to axially symmetric free jets.

The final section of this work is concerned with the slender-body theory. First of all, the author summarizes the familiar results for the flow past bodies of revolution, and then discusses the generalization of these results to bodies with arbitrary cross-sections. Here the results are obtained by direct solution of the wave equation and not by the operational methods by which they were originally discovered. To many readers the direct solution of the wave equation will seem to be a distinct advance. These methods are then applied to winged bodies of revolution, giving the effects of wing-body interference.

There can be no doubt that the present volume is a most welcome addition to the series of Cambridge monographs and that it will long continue to have a permanent value as an authoritative account of the linearized theory of steady high-speed flow. No mathematical difficulties are overlooked, and the physical significance of the mathematical equations is always kept well in mind. Perhaps some readers will put down this volume with a certain sadness—it deals so completely with the linearized theory that nothing seems to be left to be attempted by research workers but a few special problems and the great challenge of second-order theories and the full non-linear equations of compressible flow.

G. Temple

RESEARCH AT HARWELL

Atomic Energy Research at Harwell

By K. E. B. Jay. Pp. xii + 144 + 19 plates. (London: Butterworths Scientific Publications, 1955.) 5*s*.

As stated in the introduction to the book, this report carries forward the story of the Atomic Energy Research Establishment, Harwell, from the point at which it was left in a previous publication[1], and also contains some material which, either for reasons of secrecy or lack of space, could not be included in the first account. It is divided into two parts: the first, written primarily for the non-technical reader, deals with the major programmes of the Establishment, while the second, for the scientific reader, attempts to treat in more detail certain selected aspects of research at Harwell.

If one compares the two parts of the volume, it appears that Part 2 rather misses its target. The difficulty of giving in sufficient detail, in such a short space, an account of the many interesting fundamental researches being carried out at Harwell is well-nigh insurmountable, and it might have been better to give a more general description together with a list of topics and the appropriate references to the published literature.

Part 1, on the other hand, contains a very interesting and readable account of the major programmes in applied research. Beginning with a brief explanation of the relation between Harwell and the Industrial Group[2], there follows an excellent account of the progress made in reactor design and of the problems remaining to be solved if electrical power is to be produced economically from nuclear energy. Chapter 3 gives a clear picture of the increasing use of radioactive isotopes in medicine, research and industry, and of the large part played by Harwell in this process. There follow chapters devoted to other aspects of work at Harwell, to the relations between the Establishment and British universities and other research institutions, while last, and by no means least, an outline is given of some of the human and administrative problems involved in the running of an organization of this size. In addition to diagrams where necessary, there is a number of excellent photographs.

The author has contrived to give, in a short space, a good account of what goes on at Harwell, and the publishers are to be congratulated on producing this volume at such a low price. To those who, like the reviewer, believe in getting value for their money, this volume may be safely recommended.

P. J. Grant

[1] "Harwell—the British Atomic Energy Research Establishment, 1946–1951" (London: H.M.S.O., 1952).

[2] "Britain's Atomic Factories", by K. E. B. Jay (London: H.M.S.O., 1954).

HIGH-ENERGY NUCLEAR PHYSICS

PHYSICAL SOCIETY'S SUMMER MEETING

THERE are now three machines in Great Britain which can produce π-mesons in useful numbers. These are the 1,000-MeV. proton synchrotron at Birmingham, the 400-MeV. synchro-cyclotron at Liverpool and the 300-MeV. electron synchrotron at Glasgow. All three accelerators have been in successful operation for some time, and the first experimental results are beginning to appear. It was therefore timely for the Physical Society to devote the whole of its provincial summer meeting, held during July 5–6, to high-energy nuclear physics. The choice of Liverpool as a meeting place was particularly appropriate in view of the striking success recently achieved there in the extraction of the beam from the synchro-cyclotron. Members of the Society and visitors had an opportunity during the meeting of visiting the Nuclear Research Laboratory of the University, where, in addition to the 400-MeV. synchro-cyclotron, a 37-in. cyclotron and a 1-MeV. high-tension accelerator are also in operation. The average attendance at the meetings was about 150, and some seventy members joined in the conference dinner held in the University Staff House on July 5.

The scientific programme was preceded by a short business meeting, during which the president of the Physical Society (Prof. H. S. W. Massey) expressed his pleasure at the opportunity offered to the Society of visiting Liverpool. In reply to this, Prof. H. W. B. Skinner welcomed the Society, and in particular a number of overseas visitors, to what was possibly the first conference on work with high-energy machines outside the United States. The subsequent papers and discussions left little doubt that high-energy physics is now a flourishing subject in Great Britain. It was particularly interesting to note that the high-energy accelerators are being used by groups of workers from many laboratories, and that collaboration of this sort is likely to increase. In the present report, only the names of those actually presenting the papers are given, although those of their co-workers were in general scrupulously announced at the meeting.

The papers presented on the first day were all concerned with the interaction of high-energy neutrons and protons with matter. Several papers described work carried out at Harwell, where the 150-MeV. synchro-cyclotron, although not useful for π-meson production, was the first high-energy accelerator to start working in Britain, and has been used for a large number of precise experiments in the high-energy field. T. C. Randle (Atomic Energy Research Establishment, Harwell) described a new determination of the angular distribution in (n,p) scattering at 130 MeV., which clearly shows a marked asymmetry between backward and forward scattering. T. C. Griffith (University College, London) later described another determination of the differential cross-section for (n,p) scattering using the neutron beam of the Harwell cyclotron with photographic-emulsion recording of the recoil protons. His results cover the angular range $57\frac{1}{2}$–$82\frac{1}{2}°$ in the laboratory system and agree with those of other workers within the limits of error. Some observations of the charged particles emitted by carbon under neutron bombardment were obtained in the course of this work. P. Hillman (Harwell) reported on the observation of polarization in the scattering of 100-MeV. neutrons by free protons. This is an extremely difficult experiment, but good evidence for a real effect was presented, and the chairman (Prof. H. S. W. Massey) emphasized its importance for a proper analysis of nucleon-scattering work. Another interesting and informative experiment of a similar nature using the 100-MeV. neutrons from the Harwell machine was described by R. Wilson (Oxford). He and his colleagues have been able to observe the Coulomb scattering of neutrons, due to the motion of the neutron magnetic moment in the electric field of the nucleus. This scattering was predicted by Schwinger and is observable only at forward angles of less than 1°. In this region, interference between the Coulomb and nuclear scattering gives a polarization effect and enables the polarization of the initial neutron beam to be demonstrated. J. M. Dickson (Harwell) described polarization effects observed at angles between 3° and 20° in the scattering of polarized protons by carbon, aluminium, copper and silver. The effect of the interference between Coulomb and nuclear scattering in the asymmetry was very clearly shown. Both the (p,p) and the (n,p) experiments were remarkable for the angular precision achieved. Later in the meeting, A. Roberts (Rochester, U.S.A., and U.S. Office of Naval Research, London) reported on earlier (n,p) polarization experiments at Rochester which are in agreement with the Harwell results, and cover a wider energy range. He also described (p,p) polarization work and showed how the polarization produced in the scattering of protons by carbon is zero near the first diffraction minimum.

L. Riddiford (Birmingham) described the results of a study of the (p,p) interaction at about 650 MeV. using protons accelerated in the Birmingham synchrotron. At this energy the differential cross-section for elastic scattering may be influenced by the possibility of meson production, and a forward peak might be expected, in contrast with the isotropic distribution obtained at lower energies. The results for 131 events, which were obtained with a diffusion cloud chamber filled with hydrogen to a pressure of 25 atmospheres and operating in a magnetic field of 13 k.gauss show this feature. Of the inelastic events in hydrogen, forty-five examples of π^+-meson production and nine examples of π^0-meson production were identified. Angular correlation measurements made for the cases of π^+-meson production were in agreement with the hypothesis of an excited state of the nucleon-meson system corresponding to the $T = 3/2$ resonance observed in meson–nucleon scattering. W. O. Lock (Birmingham) reported on a similar study using 950-MeV. protons from the Birmingham machine. Collisions with hydrogen were obtained and recorded in nuclear emulsions, and the events were studied independently at Birmingham, Belfast and Glasgow. In this work a marked deviation from isotropy was also seen at forward angles, including a dip near 0°, which may still be due to poor statistics. The experiment gives a cross-section for (p,p) elastic scattering at 950 MeV. of $15{\cdot}5 \pm 3$ mb.; no evidence for appreciable polarization of the beam

scattered out of the synchrotron at 4° was found. In the same exposures 'quasi-elastic' collisions of the incident proton with bound protons in the heavier nuclei of the emulsion are recorded, and identification and analysis of these events was described by W. M. Gibson (Belfast).

Some discussion took place on the effort spent in analysing experiments made with photographic plates and diffusion cloud chambers. The great experimental advantages conferred by the availability of a continuous, intense and homogeneous external beam were clearly brought out in a paper by J. R. Holt (Liverpool) on the elastic scattering of protons by hydrogen at 380 MeV. The differential cross-section at 90° was found by coincidence counting using the carbon–polythene difference method; and a result of 3·63 millibarns, with an accuracy of about 1 per cent, was obtained. The excellent conditions available at Liverpool for precision high-energy experiments in the 400 MeV. region were well shown in this work. Another example of the type of work now possible at Liverpool was given by A. Ashmore, who presented the results of measurements of neutron total cross-sections for a number of elements using the transmission method with a scintillation telescope.

Towards the end of the first day, Prof. Massey reviewed progress in high-energy scattering and polarization phenomena, referring in particular to the very precise work which has now been reported from the 660-MeV. Moscow synchro-cyclotron. He stressed the fact that advances in experimental technique have been extremely rapid, and that it is now possible to envisage triple- and quadruple-scattering experiments which could determine uniquely the unknown parameters in the general nucleon–nucleon scattering matrix.

The second day of the meeting was devoted to miscellaneous topics. The Glasgow electron synchrotron was described by W. Macfarlane; it now produces 4×10^{10} equivalent quanta per min. for a pulse-rate of 5 per sec. and an energy of 340 MeV., which appears to be better than the performance of comparable American machines. The beam has been collimated to $\frac{1}{4}$ in. diameter at 125 cm. from the synchrotron. Arrangements for monitoring the beam with a pair spectrometer were described and some excellent expansion-chamber pictures of photon-induced stars in air were shown. The Glasgow synchrotron will be used in part for a study of the photoproduction of π-mesons, and E. H. Bellamy reported preliminary observations on the ratio of π^+- to π^--mesons produced in calcium; nuclear emulsion detectors were used, and the ratio was found for three energy ranges. R. G. Moorhouse (Glasgow) reported on new calculations on the photoproduction of mesons, referring in particular to the effect of $E2$ transitions on the angular distribution of mesons.

Several papers were devoted to the properties of π-mesons. S. W. Barnes (Rochester, U.S.A.) described measurements of the absolute differential cross-section for the elastic scattering of π^+-mesons by protons at centre-of-mass angles of 43° and 90°. The meson energy was 43 MeV. and a liquid hydrogen target was used, with ring-shaped crystals to define and detect the scattered mesons. By combining the two measurements with an earlier and less accurate determination at 180°, the following values for the s- and p-wave phase-shifts in the isotopic spin state $T = 3/2$ for a meson energy of 43 MeV. were obtained: $\alpha_3 = -4{\cdot}3°$; $\alpha_{33} = +4{\cdot}4°$; $\alpha_{31} = -1{\cdot}35°$. A. Roberts (Rochester, U.S.A.) in a later paper pointed out that in a scattering experiment the effects of π-mesons in more than one state of orbital motion with respect to the scattering centre are usually superimposed. In a π^--mesonic atom, however, in which a π^--meson exists for a finite time in a Bohr orbit about the central nucleus, pure states of orbital motion exist. The electromagnetic transitions in such an atom thus directly relate the energies of states such as $1s$, $2p$, $2s$, $3p$. The Coulomb energies of these states can be calculated very accurately, and the nuclear shift of the energy-levels can then be deduced from experimental observation of the mesonic X-rays. Dr. Roberts described an accurate determination of the $2p - 1s$ transition energy (K_α and K_β) in the mesonic K-series of oxygen; 40-MeV. π^--mesons were brought to rest in oxygen, and the X-rays, of energy 164 ± 4 keV., were detected in a sodium iodide crystal. An upward nuclear shift of the $1s$ level was established, showing that there is repulsion in the s-state of motion between a meson and a nucleus. The nuclear shift has also been determined for other atoms by workers at the Carnegie Institute, Pittsburgh; unfortunately, it has not yet been possible to measure it for hydrogen. Some similar observations of the $2p - 1s$ transition energy in μ-mesonic atoms were reported by F. D. S. Butement (Harwell), whose work was carried out using μ-mesons produced by the decay of π-mesons from the Liverpool cyclotron. For copper a value of 1·55 MeV. was obtained for the unresolved doublet and for lead 5·84 MeV. These values agree with the earlier work of Fitch and Rainwater and lead to the expression $R = 1{\cdot}19 \times 10^{-13} A^{1/3}$ for the electromagnetic radius of a nucleus of mass number A.

J. M. Cassels (Liverpool) spoke on total cross-section measurements with positive and negative π-mesons from the Liverpool cyclotron. It is hoped soon to exploit the intense external beam of the machine as a source of high-energy π^+-mesons, which are usually difficult to extract from orbital accelerators; but in this work an internal target and the same channel (with reversed cyclotron fields) were used for both π^+- and π^--mesons. The meson energy was 85 MeV., and total cross-sections were found by the transmission method using a scintillation counter telescope. Observations of the loss cross-section were made with different angles of acceptance for the final crystal, so that the loss due to Coulomb and diffraction scattering (counted as elastic processes) could be distinguished from that due to nuclear absorption (counted as inelastic processes). The results presented were:

Nucleus	Absorption cross-section (millibarns) π^-	π^+	Error (per cent)
Carbon	367	283	8
Aluminium	684	563	
Copper	1,420	960	
Cadmium	2,190	1,440	
Lead	3,400	2,280	5

The difference between the π^+- and π^--absorption cross-sections for the heavier nuclei may be explained by a simple Coulomb effect, but this is not adequate to interpret the results for carbon. The nuclear radius for lead deduced from the observed cross-sections is 95×10^{-13} cm., compared with a value of $7{\cdot}2 \times 10^{-13}$ cm. estimated otherwise. so that the lead

nucleus appears completely black to both types of charged π-meson at an energy of 85 MeV.

Some details of the interaction of high-energy protons with complex nuclei were presented by workers from Birmingham. W. E. Burcham and J. L. Symonds described a measurement of the absolute cross-section for the $^{12}C(p,pn)^{11}C$ reaction with proton energies between 250 and 950 MeV. The cross-section for carbon-11 production falls off slowly over this energy-range to a value of $20{\cdot}5 \pm 1{\cdot}1$ millibarns at 950 MeV. The ratio of sodium-24 and fluorine-18 activities from aluminium bombarded by high-energy protons to carbon-11 activity from polythene bombarded by the same protons was also found for the same range of energies using the internal beam of the Birmingham synchrotron. D. L. Anderson described a special type of photographic emulsion camera which has been installed in the vacuum system of the Birmingham machine. The magnetic field of the machine was used for resolution, and the energy distribution of protons scattered inelastically from carbon was obtained. For low proton energies the results are consistent with a Gaussian distribution of internal momentum in the carbon nucleus.

The day's proceedings included two technical papers of particular interest. K. J. Le Couteur (Liverpool) described the calculations which he had made on the Tuck–Teng system of beam extraction. These calculations were the basis of the design of the peeler and regenerator fields installed in the Liverpool cyclotron. When tried, it was found that the system behaved as anticipated, and that it was possible to shift the circulating beam laterally a large distance in one turn. About one-fifth of the circulating beam was made to enter a magnetic channel and 3 per cent of the internal beam, with an energy of 380 ± 2 MeV., was obtained at the end of the channel. After concentration with a focusing magnet, 2 per cent of the internal beam was measured on a target of about 1 in. diameter at a distance of 40 ft. from the cyclotron. The resulting flux of 4×10^{10} protons per cm.^{2} per sec. is about a thousand times better than has been obtained on other machines, and has been a major contribution to the efficient utilization of existing high-energy accelerators. The accelerators of the future must, however, reach much higher energies than any at present attained, and the development of new ideas in this subject was reviewed by W. Walkinshaw (Harwell). The application of the principle of alternating gradient focusing to synchrotron-type accelerators has been thoroughly investigated and underlies the design of the 25-GeV. machines now under construction at Geneva and at Brookhaven. The great expense of these machines has, however, stimulated several groups to consider alternative designs, and those proposed by the Mid-western Universities Research Association of the United States (*M.U.R.A.* group) were discussed in some detail. These envisage a magnet which is excited by direct current and are described as *FFAG* (fixed-field alternating-gradient) machines. Essentially, fields of special shape are used to confine a large range of momentum within a small range of radius. Typical design figures were presented. There is also the possibility of a fixed-field alternating-gradient constant-frequency cyclotron for an energy of perhaps 2 GeV. with a current of perhaps 100 micro-amperes. The remarkable possibilities for experiment opened up by such designs make it essential to complete detailed studies of their practicability and cost as early as possible.

W. E. Burcham

FOOD MICROBIOLOGY AND PUBLIC HEALTH

A ONE-AND-A-HALF day symposium on "Food Microbiology and Public Health" formed part of the summer conference organized by the Society for Applied Bacteriology, held in Cambridge during July 3–6. Sixteen papers were contributed by authorities in various aspects of the subject from different parts of the world, and the chairmen at the three sessions were the president of the Society, Mr. S. B. Thomas (Aberystwyth), Colonel H. J. Bensted (Colindale) and Dr. G. S. Wilson (London). Several of the contributors described individual outbreaks of bacterial food poisoning and traced so far as possible the likely sources of the trouble. The whole tone of the meeting was directed not to the dangers of food poisoning in itself, but to the dangers arising from ineffective processing, careless handling or unsatisfactory storage conditions.

The first section of the symposium dealt with milk and synthetic cream products, and K. W. Newell (Colindale) described an outbreak of infection in several families arising from eating chocolate éclairs. Fæcal coli and a few *Salmonella paratyphi* were found in the cake mixture and also in the mixing machine; but the principal contamination was *Salm. thompson*, traced to a single delivery of an unusual pack of Chinese frozen eggs, from which two other strains were also isolated, *pullorum* and *aberdeen*. Describing the method of sampling and of isolating the contaminants, Betty Hobbs and Muriel Smith (Colindale) considered that incubation in selenite medium followed by plating on Leifsen medium containing 1 per cent of sucrose is the most satisfactory method. In reply to questions, Dr. Hobbs said that these organisms can survive for more than a year in the frozen state, and that *Salm. pullorum* cannot be used as an indicator organism, partly because no really satisfactory isolation media have yet been devised.

Custard was the next topic discussed, and R. M. Fry and Joan Boissard (Cambridge) described a sudden outbreak of sore throat, pyrexia and collapse in one section of an army camp following an evening meal which included this comestible. Most of the cases were reported within 48 hr. of taking the meal, and nearly all of the throat swabs yielded cultures of *Streptococcus pyogenes*, Type 9. The incidence of infection pointed to one cauldron of custard handled by one particular cook as the source of the trouble. Doubts were expressed at first concerning this finding, because the material had been handled hot; but it was shown in the laboratory that, although the bulk of material might be at a high temperature, the skin of the custard was relatively cool and so would allow survival of infected droplets falling on the surface.

Emphasis was placed on the importance of the correct handling of dried milk by H. B. Hawley and Margaret Benjamin (Yeovil), because growth of bacteria, and especially of staphylococci, can take place readily at certain stages of processing. They described the design of a suitable drying plant, and said that growth takes place particularly at the 'evaporated milk' stage. For this reason, regular daily cleaning of the plant is essential. The staphylococcal species in the dried milk are different from those in the original milk, pointing to human or airborne contamination gaining access during processing. Coliforms die out quickly in the dried

powder, but micrococci are relatively resistant. Betty Hobbs (Colindale) quoted eight outbreaks of staphylococcal food poisoning occurring during the summer of 1953, all of which were traced to 'cream' made with dried milk. Growth of staphylococci in the cream was relatively slow, hence the poisoning must have been due to the heat-resistant toxins remaining in the dried milk. Seven of the outbreaks were from milks processed by one manufacturer, and the infection was always found in batches made towards the end of each day, a point which underlines the importance of regular daily cleaning of plant.

In a paper on fæcal bacteria occurring in citrus juices, Prof. M. D. Appleman (University of California) said that interest was aroused because of the increasing consumption of unpasteurized juices. Although the juices are at *p*H 4 (approximately), a number of types of micro-organism can survive, and even grow, to cause spoilage. High counts invariably mean that unsound fruits have been used or that they have been handled carelessly. Although coliforms occur with some frequency, fæcal streptococci appear to be the best organisms for indicating general contamination. A recorded contribution from M. W. Wilson and E. F. Mackenzie (Melbourne) described first the methods used in the State of Victoria for identifying carriers and isolating cases, and then went on to discuss in detail several outbreaks, generally occurring in young persons, of *Salmonella* infections of the *senftenberg* type. All were traced to confections containing desiccated coconut supplied from Papua and distributed by two wholesalers in Victoria. Several *Salmonella* species were isolated, including *Salm. oranienburg*, *potsdam* and *senftenberg*, originating obviously from the ecological conditions obtaining in one factory in particular. In the subsequent discussion it was stated that the heat resistances of the different *Salmonella* types vary considerably. The query was also raised that, although a certain heat treatment may have been applied, what was the actual temperature attained by the particles, and what was the moisture content ? ; these factors would affect the lethal efficiency of the heating.

In the section devoted to meats and fish, J. M. Shewan and J. Liston (Aberdeen) discussed food poisonings caused by fish. The normal bacterial flora are non-pathogenic, and generally fish is stored sufficiently cool to prevent undue bacterial growth ; but occasional pathogens are found in fish living in polluted waters. Type *E* botulism occurs in fish taken near Continental ports, but it has not been found in British waters. Particularly susceptible is the mackerel–tunny group, and poisoning seems to be due to histidine being converted to histamine during ripening. Tropical fish are much more poisonous than temperate ones, the poisons usually being of the neurotoxin or histamine type. Turning to fresh meats, the conference heard a paper by H. Lundbäck (Stockholm) on two extensive *Salmonella* outbreaks occurring in 1953, one being due to *Salm. typhimurium*. This had its source in one slaughterhouse in southern Sweden from which pork meat was found to be more heavily infected than veal. It was not possible to determine on the evidence available whether the infection was of animal or human origin. Fifteen per cent of the staff were found to be carriers at one stage.

M. Ingram and Ella Barnes (Cambridge) reported that feeding antibiotics to animals may alter significantly the microbial flora found in the gut, eliminating, for example, the streptococci and clostridia, and this may improve the quality of certain meats and reduce spoilage. This has been shown to be the case after feeding with aureomycin and to a less extent with neomycin. Only the yeasts are resistant, but this can be overcome. Dipping freshly killed meat in an antibiotic solution improves its keeping quality. Although this method is of undoubted advantage, there remain the toxicity and the medico–legal aspects to be considered.

As might be expected, cooked meats are equally, if not more, susceptible to bacterial infection, and A. A. Miller and F. Ramsden (Preston) described two fairly large outbreaks of *Salmonella* infections occurring some two years ago from consuming meat pies. In both outbreaks, *Salm. morbificans* was the cause, the infections being of animal origin. Subsequent investigations showed that inadequate baking was the reason for the spread of the infection ; it was also made clear that adequate precautions must be taken after baking to prevent the access of infection, for example, when adding the gelatin filler. R. Buttiaux and H. Beerens (Lille) discussed the incidence of gas-forming *Clostridia* in canned meats, and found ninety such infections from 109 cans examined. *Cl. welchii* occurred most frequently, followed by *Cl. bifermentans*, and all originated from semi-preserved meats or processed meats inadequately heated. Using a 'micro-ham' medium, recommended for isolating the cultures, *p*H was found not to be significant in preventing growth ; 4 per cent of salt was ineffective, but higher concentrations were ; and nitrite and nitrate were ineffective at 0·02 per cent and 0·1 per cent, respectively.

In the last section of the symposium, concerned with bacteria causing food poisoning, Prof. S. Hauge (Oslo) discussed the role of aerobic spore-formers. Four outbreaks in Oslo were traced to *Bacillus cereus* occurring in dessert sauces. Although, in every case, the infection was very high, it was not detected organoleptically. The poisoning is not an infection but an intoxication, and the symptoms are similar to *Cl. welchii* poisoning. According to Joan Taylor (Colindale), it is possible that some outbreaks may be due to mixed infections such as that of *Proteus* and *Bact. coli*. Coliforms themselves are not generally pathogenic, but in this connexion the host may be important. In Britain they form 8 per cent of the cases of 'known cause'. Considering the coliform group generally, special serological types of *Bact. coli* have been identified with certain infections, and of the remaining organisms, *Ps. pyocyanea*, *Proteus* and the paracolons, the evidence against them is mainly circumstantial. B. Moore (Exeter) said that valid cases have been proved of food poisoning due to *Streptococcus faecalis*, of which there appear to be two types, one with a short incubation period and one with a longer one. In all cases a very heavy infection is necessary to produce the symptoms, and from laboratory tests with experimental animals the medium and the age of the culture are important in determining toxicity. Type *E* botulism, first detected in 1936, has been the cause of several outbreaks on the Continent ; it has never been detected in Britain. H. O. Pedersen (Frederiksberg) said that infection is associated exclusively with fish, the toxin being produced only if the organism is incubated below 37° C. The organism has been found in various soils and sea muds, particularly those in harbours, hence the significance of fish in conveying infection. It has

certain cultural peculiarities and the spores are readily killed by mild heat.

The full papers of the symposium will appear in a forthcoming issue of the *Journal of Applied Bacteriology*.

PROTECTION AGAINST IONIZING RADIATIONS

THE rapidly widening range of applications of atomic energy and artificial radioactivity and the increasing concern and speculation on the part of the general public concerning the biological effects of ionizing radiations make the publication of the latest recommendations of the International Commission on Radiological Protection* an event of major importance. The Commission functions under the auspices of the International Congress of Radiology, which held its seventh meeting in Copenhagen in 1953.

The history of radiation protection extends back as far as 1921, to the inauguration in the United Kingdom of the British X-ray and Radium Protection Committee working under the auspices of the British Institute of Radiology, and in the United States of the Röntgen Ray Protection Committee. The formation of these and other national committees led to the first International Commission on Radiological Protection in 1928. Since that time the Commission has met at regular intervals, and its expanding sphere of interest may be judged by comparing the present 92-page report with the last recommendations issued, in 1950, comprising some eight pages in print. The British X-ray and Radium Protection Committee has recently handed over its responsibility to other committees meeting under the auspices of the Ministry of Health and the Medical Research Council, and these bodies have set up a joint Radiological Protection Service to advise users in the United Kingdom on all matters relating to protection.

The present Commission includes members from ten nations and has five sub-committees dealing respectively with the permissible dose for external radiation, the permissible dose for internal radiation, protection against X-rays up to three million volts, protection against X-rays above three million volts and against heavy particles, and the disposal of radioactive wastes and handling of radioactive isotopes. The report gives the recommendations of the first four of these; the report of the sub-committee on the handling and disposal of radioactive materials will be published later as an addendum.

In formulating its recommendations, the Commission recognizes that any significant departure from the environmental conditions in which man has evolved may strictly entail some hazard. Since no radiation-level above the natural background due to terrestrial radioactivity and cosmic rays is absolutely safe, the problem is to choose a practical level that involves a negligible risk. The concept invoked here is that of a "maximum permissible weekly dose" of radiation or a "maximum permissible body burden" of a radioisotope such that if exposure at this level were continued indefinitely, no appreciable bodily injury would be expected to result during the lifetime of the exposed individual. The recommendations are primarily intended to apply to the occupational exposure of personnel forming only a small fraction of the community, and in such circumstances genetic changes affecting the race as a whole are not considered the limiting factor. The report suggests a reduction of all permissible levels by a factor of 10 to take account of possible genetic effects where exposure of a large population is involved.

Past recommendations of the Commission have been chiefly concerned with the establishment of a maximum permissible weekly dose in röntgen units for whole-body exposure to X- or γ-radiation, and in 1950 this was fixed at 0·3 r./week. The sub-committee on the permissible dose for external radiation does not now recommend any change in this basic value for X- and γ-rays up to 3 MeV., which remains at 0·3 r./week, corresponding approximately to an absorbed dose in soft tissue of 0·3 rad/week. Maximum permissible levels for other types of ionizing radiation are also considered.

Some confusion may result from the multiplicity of units used in the report for the expression of radiation dose or radiation absorption in tissue. This arises in part from the fact that shortly before its publication the International Commission on Radiological Units recommended that the rad should be used wherever possible as the unit of absorbed radiation dose. This unit is equal to an energy absorption of 100 ergs/gram. Because of the varying biological effectiveness of different types of radiation, it is found necessary to introduce a further unit—the rem—which is defined on p. 19 as "the absorbed dose of any ionizing radiation which has the same biological effectiveness as 1 rad of X-radiation . . ." This appears to be at variance with previous definitions of the rem as that dose which has the same biological effectiveness as 1 röntgen of X-rays. The use of the rem might have been avoided had the Commission chosen to recommend that the maximum permissible dose for heavy ionizing particles should be that for X- or γ-rays divided by the relative biological effectiveness of the radiation in question. It must be pointed out that the relative biological effectiveness for any given radiation may depend on the type of biological effect studied.

On p. 17 it is assumed that the tissue dose in rads is approximately numerically equal to the dose in röntgens in the tissue concerned. It should perhaps be emphasized that this assumption is only valid in soft tissue where the mean atomic number is nearly equal to that of air. Some clarification of these issues would be welcome in future recommendations of the Commission.

Radiobiological studies have demonstrated that certain organs of the body—notably the skin, blood-forming organs, gonads and eyes—are particularly vulnerable to radiation damage. Special consideration is therefore necessary with highly non-uniform distributions of radiation dose such as may be encountered in exposure to particulate radiation. For this purpose, the concept of the 'critical organ' is introduced; by this is implied the organ of the body which under the conditions of the exposure receives the dose that results in the greatest bodily damage. The criterion used in establishing maximum permissible levels is that the dose absorbed by the critical organ shall not exceed 0·3 rad/week of X- or γ-rays or an equivalent amount of other radiation.

The idea of the 'critical organ' is fundamental to the report of the sub-committee on the permissible

* Recommendations of the International Commission on Radiological Protection (Revised December 1, 1954). British Journal of Radiology Supplement No. 6. Pp. x+92. (London: British Institute of Radiology, 1955.) 10*s.* 6*d.* with paper cover, 12*s.* 6*d.* with cloth cover.

dose for internal radiation, which considers the hazards due to ingestion or inhalation of radioactive materials. Taking account of the non-uniform distribution of radioactive material in the body, maximum permissible levels of concentration in air and drinking water are quoted for ninety-one isotopes or mixtures of isotopes. For most of these, the criterion used is that of the absorbed dose in the critical organ, the calculations being based on a "standard man" in whom all characteristics are chosen to be those representative of the average man. In the case of α-emitting radioisotopes that become localized in bone, however, the levels are based on a direct comparison with radium. A large accumulation of human experience is available regarding the effects of ingested radium in man, and the maximum permissible body burden of this element has long been fixed at 0·1 μc.

With many other isotopes, human data are usually completely lacking, and distribution and turnover must be estimated in other ways, for example, from the results of animal experiments. The sub-committee acknowledges that these calculations are often only approximate. Moreover, the figure of 0·3 rad/week applies properly to whole-body radiation, and its extension to partial-body irradiation of a critical organ may entail a considerable safety factor—a factor which may, however, be offset by irregularities in the distribution of radioactivity in the tissues of the critical organ itself, especially at the histological level. It is probable that many of the values quoted in this section may have to be revised as more detailed data become available regarding the effects of partial body irradiation and the non-uniform distribution of radioisotopes in tissue. Meanwhile, they form a valuable working guide for persons working with radioactive materials, though some may regret that the data were not presented in a more abbreviated and simplified form.

In the report of the sub-committee on protection against X-rays up to 3 MeV., detailed recommendations are given for the planning, surveying and monitoring of new X-ray installations. Principles to be followed in establishing general working conditions in such installations are outlined and the special requirements of medical diagnostic, medical therapeutic, and non-medical units are discussed separately. The hazards arising from non-useful sources of X-rays (cathode ray oscillographs, television tubes, transmitting valves, etc.) are also discussed. A valuable appendix provides data on the absorption of X-radiation in various shielding materials, and the protective barrier requirements of different types of installation.

Finally, the sub-committee on protection against X-rays above 3 MeV. and against heavy particles recommends a maximum permissible weekly dose of 0·3 rad/week for X-rays above 3 MeV., and 0·03 rad/week for neutrons in the energy range 0·025 eV.–10 MeV., assuming a relative biological effectiveness of 10 for neutrons in the critical organ—in this case the eyes. Values of neutron flux corresponding to the maximum permissible dosage rate at different energy levels, and relative biological effectiveness figures for different types of particulate radiation are specified.

The report is an impressive example of international co-operation and should receive the serious attention of all who are concerned in the production, handling, and use of radioactive materials and machines producing ionizing radiations. E. H. Belcher

OBITUARIES

Prof. G. F. Shirras

Prof. George Findlay Shirras, who died on June 23, came of an Aberdeen business family, and was educated at Robert Gordon's College in Aberdeen and at the University of Aberdeen, where he distinguished himself outstandingly in economics. Choosing an Indian career, he joined the Indian Educational Service, and at the early age of twenty-four he became professor of economics in Dacca College and was elected a Fellow of the University of Calcutta. For thirty years thereafter he held a succession of posts, doubling some of them. During 1910–13 he served in the Finance Department of the Government of India, and during 1914–21 he was director of statistics, as well as reader in economics in the University of Calcutta. He next spent five years as director of the Labour Office of the Bombay Government, and thereafter he was principal and professor of economics in Gujarat College, University of Bombay, until he retired in 1939. He then undertook the headship of the Economics Department in University College, Exeter, for the period of the War. He worked for a time in the Control Commission for Germany as controller-general of the Finance Division.

Work more to his taste awaited him elsewhere. He held the professorship of economics for a year in Trinity College, Dublin, and in the following years he worked as visiting professor and lecturer in several American universities, notably at Illinois, Florida and Cornell Universities.

Shirras wrote and published on a large scale and with authoritative effect in the field of statistics. Two weighty books sprang from his Indian experience —"Indian Finance and Banking" and "The Science of Public Finance", and also "Some Aspects of Indian Commerce and Industry". Others of his publications were "Federal Finance in Peace and War" and "Planning towards Recovery". He undertook research and wrote on Sir Isaac Newton, being attracted by Newton's work at the Mint, and he contributed to the "Encyclopædia Britannica". A book entitled "The Burden of British Taxation" came out in 1943.

His enthusiastic spirit conceded nothing to advancing age or to his status of retirement. He may truly be said to have been the victim of his arduous concentration on work and his intense interest in problems and people. He was alert and responsive, whatever the occasion or the company, lucid and engaging in speech and gifted in writing. He wrote, moreover, a scrupulously clear and graceful hand. Large-headed, of striking features, and virtually bald, he had a rare distinction of appearance. Outside economics, his chief study was the Bible, especially the Psalms, and the Saints. Born a Presbyterian, he became an Anglican, and officiated frequently and acceptably as a lay preacher.

He died prematurely, it may justly be said, a little before his seventieth birthday. He died, as he would have wished, in harness, on his way to take part in the conference of the International Statistical Institute at Rio de Janeiro.

Shirras married Amy Zara, the only daughter of the late George McWatters, who survives him. Of his two sons, Major Richard Shirras and Major Douglas Shirras, the latter was killed while serving in France with the Seaforth Highlanders.

Dr. Stanley Smith

Dr. Stanley Smith was born at Middlesbrough on March 7, 1883, and educated at Darlington Grammar School. On leaving school he worked in the chemical laboratory of the Darlington Forge Co., but in 1904 he entered Armstrong (now King's) College, Newcastle on Tyne, where he graduated in 1907, and took his M.Sc. and D.Sc. degrees in 1909 and 1915, respectively.

Inspired by Prof. G. A. Lebour, Stanley Smith carried out investigations on the coalfields of Northumberland and the Carboniferous Limestone of the fells, his resulting paper (1911) on "The Faunal Succession of the Upper Bernician" being still a standard work. But, of greater importance, this research led him to take up the study of the Palæozoic corals, in which he thereafter specialized. Election to a fellowship at Armstrong College in 1910 took him to Clare College, Cambridge, where he graduated in 1912. His first paper on corals (1913), on ontogenesis and local variations in *Aulophyllum*, set the pattern for all his future work, for he insisted, as always, on the need for basing the revision of genera and species on the re-examination of the type specimens or, if they were unavailable, of topotypes. In his masterly paper on *Lonsdaleia* (1916), Stanley Smith write, "Inconstancy of detail, but conservation of the general plan, is the most characteristic feature of the skeletal morphology of Rugose genera", a statement repeatedly validated by later work. A stream of papers followed, either by him alone or in collaboration; these quickly established his world-wide reputation as the leading authority on Palæozoic corals. Of peculiar interest was his description (1930) of Valentian corals from Shropshire and Montgomeryshire, for, apart from H. A. Nicholson and R. Etheridge's classic monograph of the Silurian fossils of the Girvan area, no extensive coral fauna of similar age had been previously described. All his papers were marked by careful observation, honest interpretation, and polished presentation. They have acted as models for almost all Palæozoic coral research since, and, to quote a correspondent, "have really placed Palæozoic coral work on its feet".

From 1913 Stanley Smith spent much time during vacations at the British Museum (Natural History), from which sprang his long association with Dr. W. D. Lang. Their collaboration resulted not only in several important works revising an extensive range of coral genera, but also in their enunciation (1930) of the concept of genomorphs, which has since been applied to other groups of fossils. The Museum published in 1940 the "Index of Palæozoic Coral Genera", of which Stanley Smith was a part-author.

His investigations into the geology of the Bristol area led to two major stratigraphical contributions, namely, his recognition of Tremadocian Shales in the Tortworth inlier of Gloucestershire (1933), and his correlation of the high Viséan fauna of the Tanhouse Beds of Yate with the upper part of the P_2 zone (1941). With G. A. Kellaway he also described the only British Jurassic stromatoporoids known (1938), while earlier (1923) the Geological Survey had published his important report on the lead and zinc ores of Northumberland and Alston Moor. The award to him by the Geological Society of London of the Lyell Medal in 1947 for his palæontological and stratigraphical researches was richly deserved.

Stanley Smith was also knowledgeable in Greek and Roman antiquities. For some years he had been engaged with Mr. D. E. Eichholz, of the University of Bristol, on a new translation of Theophrastus's well-known treatise. His part was to interpret afresh Theophrastus's geological references and records, and to this he brought the same care and enthusiasm that characterized everything he undertook.

Stanley Smith spent his life in the university world. After appointments at Aberystwyth (1913–20), Bedford College for Women (1920–21), and Toronto (1921–22), he became assistant lecturer in geology in the University of Bristol (1922) and retired as reader in palæontology in 1948. He played a full part in local scientific societies, and had been president of the South-Western Naturalists' Union, of which he was honorary secretary for many years.

To work closely with Stanley Smith was to discover a gentle, generous nature, and a lively sense of humour which was always kindly. He was an indefatigable worker, to whom the problem of the moment was all-absorbing. He freely gave of his knowledge, though always in the humble spirit which was one of his great traits. He never lost his innate modesty nor his charming, old-world courtesy, and he would exercise the greatest patience in trying to understand another's point of view. Above all, he was a very loyal colleague and friend.

During the last few years of his life, Stanley Smith suffered from a painful affliction of his back; but despite this he kept at his research work to the end. He died peacefully on July 1, 1955, after a heart attack. His wife, whom he married in 1924, survives him.

H. Dighton Thomas

Dr. J. B. Christopherson, C.B.E.

John Brian Christopherson, familiarly known as 'Christo' to his friends, who died on July 21 at the age of eighty-seven, will be remembered for the varied and exciting career which he led as well as for the scientific work that he achieved. He will go down in medical history as the man who introduced the cure of bilharziasis (schistosomiasis) by intravenous injections of tartar emetic.

He had a good family and scientific background, being educated at Clifton College, Caius College, Cambridge, and St. Bartholomew's Hospital, London. He qualified in 1893 and soon afterwards was elected assistant surgeon to the Albert Dock Hospital under Mr. (afterwards Sir) James Cantlie, and he remained in London until 1901. Christopherson was therefore associated with the beginnings of the London School of Tropical Medicine and came under the influence of Sir Patrick Manson. In 1897 he took his final F.R.C.S. and eventually was elected F.R.C.P. in 1913. He was therefore doubly highly qualified. In 1901 he was swept into uniform and went to the South African War, becoming surgeon to the Imperial Yeomanry base hospital. After this experience, he joined in June 1902 the newly created Sudan Medical Service, first as the private doctor to the Sirdar, afterwards becoming director of medical services of the Sudan Government. Five years later he resigned this appointment and became director of the civil hospitals in Khartoum and Omdurman. He had now direct charge of clinical cases and made the most of the rich material under his care.

His career was once more broken by war, when he accompanied Sir James and Lady Berry's Red Cross Unit to Serbia as a surgeon. There he witnessed the break-up of Serbia and was taken prisoner by the

Austro–Hungarian armies. He was, however, soon rescued, and chivalrously released by Slatin Pasha, the Inspector General of the Sudan, who as an Austrian subject had stayed behind in his native country at the outbreak of war.

Early in 1916 Christopherson was in France as the secretary to the War Office Commission on Medical Establishments. Later in that year he was back in Khartoum, where he found several cases of kala-azar who were also infected with bilharziasis—*Schistosoma haematobium*. Having learned of Sir Leonard Rogers's discovery of the specificity of antimony (tartar emetic) in the treatment of kala-azar in Calcutta in 1914, he followed suit, but was surprised to see the schistosome eggs disappear also from the urine, until the cases were cured of both diseases. He also made the pregnant observation, which has since been many times confirmed, that the appearance of the eggs is changed by antimony and that they no longer hatch in water. To Christopherson must therefore go the credit for this notable discovery.

On his return to England after the War, Christopherson was in charge of the bilharzia clinic of the Ministry of Pensions and cured many ex-Service men. He then became a specialist in pulmonary diseases and physician to the London Chest Hospital, was also physician for tropical diseases to the Royal Masonic Hospital and took an interest in the tropical diseases section of the Royal Society of Medicine. More than twenty years ago he retired to his country home, where he devoted himself to horticulture. Christopherson was a sympathetic and friendly person, whose great joy was to help others. He had several endearing and attractive mannerisms; but when occasion warranted he could be tough and firm.

P. Manson-Bahr

NEWS and VIEWS

Presentation to Prof. F. J. M. Stratton, F.R.S.

On August 23, in the rooms of the Royal Astronomical Society, the president, Sir Harold Jeffreys, presented to Prof. F. J. M. Stratton a copy of "Vistas in Astronomy" at a special conversazione. Those present included foreign astronomers visiting the United Kingdom prior to the ninth General Assembly of the International Astronomical Union. On the same occasion, Prof. H. C. van de Hulst, of Leyden, received the Eddington Medal for 1955. It was originally the occasion of Prof. Stratton's seventieth birthday, after his retirement from the chair of astrophysics at Cambridge, that gave the inspiration for "Vistas in Astronomy", intended as a tribute from his former colleagues, students, friends and admirers everywhere. As publication plans progressed, and when the efforts of the editor, Dr. Arthur Beer, to obtain contributions from leading representatives of all nations met with such encouragement and an increasing number of acceptances, it became clear that this was to be something much more than a *Festschrift*. The final outcome is the present work: a generous and thorough cross-section through the whole of contemporary astronomy and its allied sciences, always emphasizing the lines along which research is particularly active at the moment, its new techniques and methods and their interaction with theoretical developments. These two volumes could be compared to the "Handbuch der Astrophysik", published in Germany before the War, although the present work is much wider in scope. It can rarely, if ever, have happened before that so many leading scholars in a single discipline have co-operated in one book on such a wide international scale; indeed, 215 authors from twenty-six nations have joined to produce 192 contributions. That this was possible is a fitting tribute to the international spirit which has permeated Prof. Stratton's life-work in and for astronomy. Practically every country in the world with an active astronomical life has contributed.

Physical Chemistry at Sheffield: Prof. George Porter

Dr. George Porter, who has been appointed to the newly established chair of physical chemistry in the University of Sheffield, is distinguished for his pioneering contributions in the field of flash photolysis and kinetic spectroscopy. He was Ackroyd Scholar of the University of Leeds, and after graduating in 1941 entered the Royal Navy, with which he served throughout the War as a specialist in the field of radar; he was demobilized in 1945 with the rank of lieutenant. He resumed his studies in the Laboratory of Physical Chemistry at Cambridge, where in due course he was awarded the degree of Ph.D. for his work on the development of the method and technique of flash photolysis. The application of this powerful method to the study of primary photochemical reactions, to the measurement of very rapid reactions between atoms and free radicals, and the reactions of explosion and combustion, has resulted in a large amount of new and important work published during the past seven years. Dr. Porter was appointed demonstrator in physical chemistry at Cambridge in 1949 and assistant director of research in 1953. He was elected to a fellowship at Emmanuel College in 1952. In 1954 he joined the British Rayon Research Association as assistant director, where he was associated with the launching of the new laboratories recently opened by H.R.H. the Duke of Edinburgh. His many friends in Cambridge and the academic world at large will welcome his return to university life, and wish him every success in the building of his new research department.

United Kingdom Agricultural and Food Representatives in Canada: Mr. Gilbert S. Lawrie

Mr. Gilbert S. Lawrie, senior inspector in the Department of Agriculture for Scotland, has been appointed agricultural and food adviser to the High Commissioner for the United Kingdom in Ottawa, in succession to Mr. W. F. Darke, who has completed his tour of duty in Canada. Mr. Lawrie, who is thirty-nine years old, was educated at George Watson's Boys College, the University of Edinburgh and the East of Scotland College of Agriculture. His academic awards include the Stevens Scholarship in agriculture and the Wardlaw–Ramsay Memorial Prize and Medal for the most distinguished student. He was president of the Edinburgh University Agricultural Society and leader of the College of Agriculture livestock judging team. His practical experience includes two years work on arable, stock and dairy farms, eleven years on work closely connected with practical farming, and a short period on the

staff of Boghall Experimental Farm. For two years he obtained commercial experience with a well-known firm of Scottish seedsmen. During the War he served in the Middle East and Mediterranean countries, and was appointed deputy assistant director of supplies with executive and advisory responsibilities connected with the production, purchase, storage and distribution of agricultural commodities and the administration of extensive War Department farms in Palestine and Syria. In 1946 Mr. Lawrie returned to Britain and joined the Department of Agriculture for Scotland, where he has served for the past nine years.

Use of Radioactive Cæsium for Cancer Treatment

THE United Kingdom Atomic Energy Authority announces that a new kind of teletherapy source for treatment of deep-seated cancer is being made available for use at the Royal Marsden Hospital, London. The principles of such treatment are not new, but this is the first time that radioactive cæsium recovered from 'waste' fission products has been used for this purpose. The source itself is a cæsium salt enclosed in a metal cylinder about one inch in diameter and three inches long. It has an activity of 1,000 curies (equivalent to that produced by a thousand grams of radium). The extraction, refinement and preparation of the source in its capsule was undertaken for the Industrial Group by the Research and Development Branch at the Atomic Energy Factory at Windscale, since the raw materials are stored there. The process is remotely operated within cells having concrete walls several feet thick, and the salt is finally melted at a red heat into the metal capsule. The initial rate of production of these sources will be one to two a month. With the exception of a single experimental source made in the United States, no other country is making cæsium on this scale. The suggestion for utilizing radioactive cæsium, which has a useful life of some scores of years, from atomic pile 'waste' arose about 1952 at Harwell, and the Isotope Division there suggested that it might be suitable for cancer therapy. The general proposal to make these sources was announced at a Hospital Physicists' Association meeting in London in November 1954, and the first hospitals to use the sources will be the Royal Marsden and Royal South Hants. These hospitals have each designed their own special therapy head to contain the sources; other hospitals may use a head designed by the Isotope Division at Harwell to suit the cæsium sources. Two of these heads were exhibited at the International Conference on the Peaceful Uses of Atomic Energy at Geneva.

Science Museum Collection: Supervoltage Machines for X-Ray Therapy

THE Science Museum, London, has recently gathered together in its Atomic Physics Collection a small group of exhibits relating to linear electron-accelerators. Although for purely research purposes the cyclic accelerators such as the betatron and synchrotron are the most widely used for the production of penetrating X-rays for hospital radiotherapy, the travelling-wave linear electron-accelerator has great advantages and is being installed in an increasing number of hospitals in Great Britain. The Science Museum exhibits comprise sectioned parts of an actual accelerator, presented by Mullard, Ltd.; a most ingenious mechanical model illustrating the principle of the travelling-wave accelerator, lent by the Metropolitan-Vickers Electrical Co., Ltd.; several diagrams showing the construction and operation of these accelerators; and a group of photographs showing them in use in the Hammersmith Hospital, London, and in the Megavolt Treatment Unit at Newcastle upon Tyne. Other exhibits in this field recently placed on view in the Museum are a betatron presented by the Clarendon Laboratory, Oxford, a model of the Philips cascade generator at the Cavendish Laboratory, Cambridge, and a mechanical model illustrating its principle lent by the Westinghouse Brake and Signal Co.

Rockefeller Grant for Genetics Research at University College, London

THE Rockefeller Foundation has made a grant of 30,000 dollars to the Galton Laboratory of University College, London, for furthering research in genetics, this grant being an extension of a similar one which has been given to the Laboratory since 1946. The work at the Galton Laboratory is exclusively concerned with human genetics, particular attention being paid to certain specific aspects. In the identification of the effects of genes in homozygous and heterozygous form by biochemical methods, precise techniques are being developed which enable the presence or absence of a gene to be established with minimal chance of error; these principles are being successfully applied to the urinary excretion of cystine and of β-amino-*iso*-butyric acid. Work on the gradual extension of knowledge concerning the human chromosome map is concerned with pairs of conditions located on the same chromosome, which have recently been discovered by members of the staff; examples are, first, the linkage between elliptocytosis and the *Rh* locus and, secondly, that between the 'nail-patella' syndrome and the *ABO* locus. For the ascertainment of the part played by genes in morphological and metrical traits, both normal and abnormal, noticeable at birth, special attention is being paid to fœtal malformations of specific types, including mongolism; the genetical contribution of the mother to weight of the child at birth is being confirmed. Finally, existing methods, and new ones, are being applied to the statistical and mathematical analysis of human genetical data, special attention being paid to the precise ascertainment of gene frequencies and the exact measurement of linkages.

Photobiology Group

A PHOTOBIOLOGY Group has been recently established in Great Britain "for the purpose of bringing together biologists, chemists and physicists with an interest in this field, to further scientific discussion in this country and to explore the possibilities of international co-operation". The members of the organizing committee are: *Chairman*, Dr. M. H. Pirenne; *Vice-Chairman*, Prof. J. A. V. Butler; *Secretary*, Dr. Edna M. F. Roe; with Dr. Ph. Bauwens, Dr. E. J. Bowen, Dr. R. Hill, Dr. A. D. Lees and Dr. N. Uri. The first meeting of the Group will be held on October 3, 10 a.m.–6 p.m., at Bedford College, Regents Park, London, N.W.1, when four papers will be read: light absorption and energy transfer (Dr. E. J. Bowen); the present state of photosynthesis research (Dr. R. Hill); photosensitive pigment in the retina (Dr. W. A. H. Rushton); and basic principles in the measurement of light energy (J. S. Preston). Those wishing to attend the meeting should write before September 19 to Dr. Edna M. F. Roe, Chester Beatty Research Institute,

Royal Cancer Hospital, Fulham Road, London, S.W.3, from whom further particulars of the Group and its membership can be obtained.

The Anthropologist: New Indian Journal

In the India of to-day many diverse populations are being brought into contact with each other. The network of communications extends to the remotest areas, and tribal cultures at all levels are meeting Western civilization at an increasing rate. This has led to an equally increasing activity in the field of anthropology both by non-Indians and Indians. A welcome is to be extended, therefore, to *The Anthropologist*, a biannual journal edited by the Department of Anthropology of the University of Delhi (Rs. 6 a year or Rs. 3.8 a copy). Although the managing director is Dr. P. C. Biswas of Delhi, the editorial board is not restricted to his Department. Among others, it includes B. S. Guha, director of the Department of Anthropology of the Indian Museum in Calcutta, and the first article in the first number is by Ernst C. Büchi of that Department. Incidentally, this is a most valuable contribution to our knowledge of the blood-group secretor factors in India, a demonstration that the secretor status will become important in recognizing the varied composition of mixed Indian communities. The same number of the journal contains a study of juvenile delinquents by P. C. Biswas, anthropometric studies of the Bhotias by S. C. Tiwari, a cultural essay on the Naiks by J. D. Mehra and papers on fingerprint patterns and blood groups. The second number has now appeared and continues along these varied lines, with contributions by Büchi, notably one on the question of sickling in Indian aboriginals, by G. R. Gayre from Saugar, S. C. Dube from Hyderabad and by the Delhi group. We can look forward to a stimulating contribution from India in this field.

Risks to Wild Life of Agricultural Chemicals

There has naturally been some concern in Great Britain lest the widespread use of chemicals to destroy pests and weeds should be a source of undesirable or even dangerous secondary effects. The risks run by operatives handling such substances and the possibility of harm from eating food exposed to them have already been discussed in two earlier reports ("Toxic Chemicals in Agriculture", 1951; and "Toxic Chemicals in Agriculture: Residues in Food", 1953). A third report, "Toxic Chemicals in Agriculture: Risks to Wild Life", has now been published (pp. 31. London: H.M.S.O.; 1*s*. 6*d*. net). According to evidence collected from a large number of organizations and individuals and some field-experiments carried out to gain information of a more precise nature, it seems that casualties to mammals and birds (including game) due to sprays are probably small. The substances most likely to be harmful are organophosphorus insecticides applied to brassicas in late summer, arsenical compounds used for potato haulm destruction, dinitro weed-killers applied in spring, and DDT insecticides applied to orchards, carrots and peas. Details of some actual fatalities that have occurred are given, and precautionary methods suggested. Danger to insects is probably much greater but more difficult to evaluate. Effects of sprays on honey bees have received special attention in view of the increasing losses reported, and closer co-operation is urged between beekeepers, farmers and spraying contractors. The inquiry has brought to light the need for research and investigation, and among lines of work suggested are the effect on birds of killing large numbers of insects and the extent to which seed production of sprayed crops is reduced by the death of pollinating insects.

Rubber Research Institute of Malaya

In the current annual report of the Rubber Research Institute of Malaya for 1952 (Kuala Lumpur, 1954), an account is given of the fourth year of operation of the five-year programme of expansion of the organization and work of the Institute. The present report contains an introduction by the Director and accounts of the work of the several Divisions—Soils, Botany, Pathology and Chemistry—each subdivided into research and advisory sections. An account is also given of the Smallholders' Advisory Service. Work on the rubber tree includes breeding and selection, a study of tapping systems, various soil investigations, cultivation and manuring, and the control of diseases and pests. Work on the product begins from the moment of tapping and continues through all the subsequent processes, that is, it includes the collection and treatment of latex and its processing through to the final product for export. These studies are in the hands of the Chemical Division. Fuller accounts of the experimental work of the Institute are to be found in its *Journal*, the annual reports being intended to fulfil a more general purpose.

Observatory Department, Mauritius: Report for 1953

The report of the Observatory Department of the Colony of Mauritius for the year 1953 (pp. 16. Port Louis: Government Printer, 1954) describes the general functions of the Department under various headings, including provisions of meteorological services for the government departments, local authorities, the press and general public, agricultural and commercial interests, the Armed Services, the merchant navy and civil aviation; warnings of tropical cyclones; research; and other activities. Besides the Royal Alfred Observatory, the Department also maintains a number of stations at Pamplemousses, Vacoas, Plaisance Airfield, Agalega, St. Brandon and other places. In addition to the director, E. G. Davy, there are an assistant director and thirty-four others on the staff. Descriptions are given of the inspections and visits, buildings, meteorological instruments, magnetic instruments and other equipment, etc. It is interesting to notice that towards the end of 1953 research work was in progress on the influence of rainfall on the rates of growth and maturity of the sugar cane. As the Colony's income depends almost entirely on agricultural products, the Department devotes most attention to agricultural meteorology. During 1953, progress in reorganizing and extending the Department was more substantial than had been possible to report in previous post-war years. This is chiefly attributed to the provision of adequate accommodation at the Vacoas headquarters, the filling of one of the posts of assistant meteorologist, and the increasing experience of observers appointed in 1949 and 1950. Further funds for building having become available and hopes of filling all staff vacancies in 1954 being entertained, the report ends on the optimistic note that "the prospects at the end of 1953 were brighter than they have been for a number of years".

Abstracts of Papers on Radio Engineering

THE amount of literature published in the field of radio and electronics is nowadays so vast that any aid to abstracts and references in the subject is very welcome. As a contribution to this end, the British Institution of Radio Engineers has recently published a booklet entitled "Abstracts of Papers which have appeared in the *Journal of the British Institution of Radio Engineers* over the Past 15 Years" (pp. 48; 1955; from the Institution, 9 Bedford Square, London, W.C.1; 2*s*. post paid). Fourteen volumes of this *Journal* have been published during this period, and the papers abstracted include those presented at the latest convention of the Institution held in 1954. The abstracts, which number nearly four hundred, are arranged according to the Universal Decimal Classification system, and the use of the booklet is facilitated by the table of contents and index to authors.

The Night Sky in September

FULL moon occurs on Sept. 2d. 07h. 59m., U.T., and new moon on Sept. 16d. 06h. 19m. The following conjunctions with the moon take place: Sept. 14d. 0h., Jupiter 5° N.; Sept. 18d. 12h., Mercury 2° N.; Sept. 20d. 16h., Saturn 5° N. In addition to these conjunctions with the moon, Mercury is in conjunction with Spica on Sept. 21d. 02h., Mercury 1° S. Mercury is too close to the sun for observation during September, and the same applies to Venus, which is in superior conjunction on September 1. Mars rises about 4h. 40m. throughout September, and during the early part of the month it is close to ρ Leonis, from which its eastward movement takes it south of σ Leonis about September 24. At the end of the month it is west of β Virginis and soon afterwards moves into the constellation Virgo. Jupiter rises at 3h. 15m., 2h. 35m. and 1h. 55m. on September 1, 15 and 30, respectively, and is conspicuous in the constellation Cancer, in which it moves eastward into Leo. Saturn has an eastward movement in Libra and sets at 21h., 20h. 10m. and 19h. 10m. on September 1, 15 and 30, respectively; its change of position is easily noticed as it moves from east of α Libræ to midway between α and γ Libræ towards the end of the month. There is no occultation of stars as bright as magnitude 6 during the month. Autumnal equinox occurs on Sept. 23d. 20h.

Announcements

H.M. THE QUEEN will open the new buildings of the School of Veterinary Medicine, University of Cambridge, on October 20.

IT is announced that Imperial Chemical Industries fellowships for research in the University of Cambridge have been awarded to Drs. B. H. Briggs and R. I. T. Cromartie (Clare College); P. W. E. Grensted (Christ's College); and O. M. Phillips (Trinity College).

THE Research Fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About £700 a year is available for this purpose, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund, and from other sources. Applications for grants should be submitted by November 15 on the appropriate form, obtainable from the General Secretary of the Society at Burlington House, Piccadilly, London, W.1.

THE Massachusetts Institute of Technology is offering a small number of scholarships to British graduates in science and technology (not architecture or town planning) to enable them to attend the summer session of the Institute during June 4–September 25, 1956. Candidates must be less than twenty-eight years of age and have done at least two years work in either industrial or academic research since graduating. Application forms, to be returned by October 14, can be obtained from the Cultural Affairs Officer, American Embassy, Room 302, 41 Grosvenor Square, London, W.1.

THE Institute of Metal Finishing has decided to revive in a modified form the William James Memorial Prize, founded in memory of its first honorary treasurer. The competition will be in the form of an essay on any aspect of metal finishing or related subject, and will comprise two sections: essays of a theoretical or technical point of view, for which competitors must not be more than twenty-five years old; and essays based on practical knowledge or experience (no age limit). Two prizes of 10 and 5 guineas, respectively, will be awarded in each section. Essays should be 1,000–5,000 words in length and may be illustrated. They should be sent not later than October 31 to the Honorary Secretary, Institute of Metal Finishing, 32 Great Ormond Street, London, W.C.1.

THE Photoelectric Spectrometry Group is carrying out a survey of the demand (in Great Britain) for solvents for spectroscopic purposes, with particular reference to the purity required at specified minimum wave-lengths and the quantities used. A questionnaire has been prepared and is ready for distribution to as wide a field of solvent users as possible. Copies of the questionnaire can be obtained from the assistant honorary secretary of the Group, K. A. Macdonald, 56 Arbury Road, Cambridge.

THE Metal Physics Committee of the Institute of Metals is organizing a one-day symposium on "The Mechanism of Phase Transformations in Metals", to be held in the Royal Institution, Albemarle Street, London, W.1, on November 9. The morning session will be devoted to transformations of the nucleation and growth type, and the afternoon session to martensitic transformations. Eighteen papers will be read. Non-members of the Institute may attend the meeting, registration forms being obtainable from the secretary of the Institute, Lieut.-Colonel S. C. Guillan, 4 Grosvenor Gardens, London, S.W.1.

A SYMPOSIUM on "Cavitation in Hydrodynamics" will be held at the National Physical Laboratory during September 14–17. There will be sessions on factors governing the inception of cavitation, experimental techniques, scale-effect factors, effects on hydrodynamic performance and cavitation damage. The opening paper will be a survey by Mr. P. Eisenberg, of the U.S. Office of Naval Research. Further particulars can be obtained from the Director, National Physical Laboratory, Teddington, Middlesex.

ERRATUM. In "Definition of the Second of Time" on p. 282 of *Nature* of August 13, it is stated, "If the position of the Moon at any time can be determined to 0·05 sec., a period of four years would be necessary to obtain an accuracy of 1 in 10^9 in time and frequency derived from astronomical observation". 0·05 sec. should read 0·05″.

CHEMICAL RESEARCH LABORATORY, TEDDINGTON

REPORT FOR 1954

UNDER the title "Chemistry Research 1954"* are comprised the report of the Chemistry Research Board, signed by the chairman, Prof. E. L. Hirst, and the report of the director of the Chemical Research Laboratory, Teddington, Dr. D. D. Pratt. To these are appended lists of committees of the Board, publications and patents in 1954, staff of the Laboratory on December 31, 1954, metals held by the Pure Metals Committee, standard substances available, and organisms deposited in the National Collection of Industrial Bacteria since publication of the catalogue. Considerable expansion in work on the purification of metals and elements required as semiconductors has been approved by the Board, and, in empbasizing the value of such special services as the provision of standard organic compounds, pure metals and cultures of industrial bacteria, the Board comments on the necessity of providing sufficient staff to prevent reduction of the general research programme. The Board has also recommended commencement of research on the purification of the five elements in addition to gallium and germanium, of interest as semiconductors—antimony, indium, selenium, tellurium and silicon. As part of an investigation on the preparation of the pure rare-earth metals, the separation of the rare earths is being studied using ion-exchange methods. On the recommendation of the Pure Metals Committee, investigations were also in progress on the preparation of pure boron at the Imperial College of Science and Technology, London, and of pure chromium at the National Physical Laboratory, Teddington. The Board's report also notes the provision by the Laboratory of highly purified benzene to a university team acquiring data on compressibility, and pure *p*-xylene to another group working on the thermodynamics of solutions, while joint work with the National Physical Laboratory, now concluded, has made benzoic acid of certified calorific value commercially available.

Other work noted in the Board's report includes the promise of zone melting as a technique for purifying organic compounds, and the pharmacological properties of 4-hydroxy*iso*phthalic acid, available as a by-product in the reaction of carbon dioxide with sodium phenoxide; the value of the chromatographic procedures worked out for the detection and determination of copper, cobalt, niobium and tantalum in geochemical prospecting; the quantitative separation of such metals as copper, cobalt, nickel and iron by elution from a cation-exchange resin by means of an organic solvent mixture; and the use of ion-exchange membranes in an electrolytic cell for separation of ions. Studies on the applications and fundamental characteristics of membranes exhibiting molecular selectivity have been extended to include an examination of the preparation and properties of ion-selective membranes, and encouraging progress has been made towards an understanding of the processes underlying the preparation of polyvinyl alcohol membranes of graded molecular selectivity. A new series of membranes prepared from methoxymethyl nylon promises to find application in industrial dialysis. It is possible that the technique used in the continuous culture apparatus, transferred from Porton to the Laboratory, may be used for increasing the efficiency of some industrial fermentation processes. A laboratory method has been developed for the production of hydrogen sulphide from sulphated raw sewage sludge; this method could be economically attractive at a time of sulphur shortage. The use of waste chromate to stop the evolution of hydrogen sulphide from a wet clay pit polluted with refuse at New Malden, Surrey, may be of wider application in refuse disposal and in the recovery of derelict areas.

The staff of the Chemical Research Laboratory numbered 183 at the end of the year, and there were some twelve guest workers, many of whom came to study special techniques used by the Laboratory. The stock of pure metals held by the Laboratory was increased to twenty-nine by the addition of cerium, molybdenum and tungsten, and the addition of naphthalene, 2-methylnaphthalene and *iso*propylbenzene brought the number of reference specimens of organic compounds to forty-four, from which 593 samples were supplied during the year. Deposition of eighty new strains brought the total in the National Collection of Industrial Bacteria to 750, and during the year 895 cultures were supplied, 522 to research and educational and 373 to industrial establishments.

The director's report again stresses the extent of the advisory work on corrosion problems, on which some 240 requests for advice were received during the year. Many of these were concerned with corrosion by fresh water as in heating systems, in hydraulic systems, and of copper pipes carrying supply waters; but the largest number of inquiries was concerned with methods of combating corrosion by sea-water. Problems of corrosion in other environments included that in oil-fired cracking units handling acetic acid and acetone, and in stainless-steel equipment in contact with the oxidation products of acetic and formic acids at high temperatures. Advice was also given on methods of film stripping and the preparation of samples for electron diffraction examination, and the use of capacitance methods for the examination of protective coatings and of radioactive tracers in studying inhibitor mechanism.

Advice was given to a rural district council confronted with a serious financial problem in the cathodic protection of more than a hundred miles of cast-iron water mains, and as a result of a survey it was possible to indicate those sections which required protection, thus saving a considerable part of the cost. Another inquiry was concerned with the external protection of small-diameter mains used for carrying the various spray fluids for pest control on fruit farms; encouraging results were obtained with cathodic protection. Many inquiries were concerned with the protection of materials and articles against corrosion in storage and transit. Advice was given on overcoming corrosion troubles in completed

* Department of Scientific and Industrial Research. Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory, for the Year 1954. Pp. iv+71. (London: H.M.S.O., 1955.) 3s. net.

watches intended for export; on the possible effect of vapour-phase inhibitors in stress corrosion and in steam lines in tobacco-manufacturing plant; on the pitting of stainless steel orifice plates stored between gaskets of impregnated asbestos; the use of *cyclo*hexylamine carbonate as an inhibitor in the upper part of oil storage tanks at Aden and for the protection of boilers, the effect of different finishes on aluminium, on the adhesion of mastics to greenhouse frames, and the accelerated production of a green patina on the Australian War Memorial at Canberra.

Samples of preparations containing 'Gammexane', divinyl ether, casein, γ-picoline, mesitylene pseudocumene, chlorocresols, substituted anisoles and other substances were examined with the infra-red spectrometer for various firms; many requests continued to be received for information and advice on distillation techniques, determination of freezing-point, methods of analysis and physico-chemical constants, and the Laboratory's high-pressure equipment was frequently used in preparative work by industrial firms and academic workers. Much advice was given on the construction and use of the osmometers and thermostat baths developed in the Laboratory for the determination of the molecular weights of polymers and on the application of ion-exchange processes to industrial problems, while many requests for assistance are now being received by the Radiochemical Group.

During the year the Corrosion of Metals Group suspended work on the use of radioactive tracers in the study of the mechanism of corrosion inhibitors and on the electrical study of boiler corrosion, and the study of boiler corrosion was intensified. The corrosion of mild steel in boiling sodium chloride was being examined, and an investigation into the corrosion of mild-steel tubes in Scotch marine boilers was continued. A systematic attempt was being made to correlate the influence of the rate of movement on the corrosion of metals immersed in neutral solutions and natural waters with other factors, especially the temperature and composition of the solution, while a survey was being made of the corrosion-inhibitive properties, with reference to abraded mild steel, of sodium salts of organic acids related to benzoic acid. An electrochemical method has been used to determine the degree of continuity of the protective coating on the inside of water mains. Work on underground and microbiological corrosion was concentrated on examinations of corroded pipes, electrical power cables and soil samples, but further work is required before a practical method of applying tannins to prevent bacterial corrosion of steel can be developed. Other work has been concerned with the effect of silicon on surface films on stainless steels, and new work has been started on wrapping materials for preventing the tarnishing of silver and copper, for which purpose incorporation of chromates of copper, lead, zinc, *cyclo*hexylamine and other amines, copper and lead phosphates, lead nitrite, chromic sulphate and chlorophyll in the paper wrapping has proved particularly effective.

Research in the Inorganic Group has again been mainly concentrated on the examination of flash roaster wastes for selenium and its recovery and on the preparation of elements and derivatives to a high degree of purity. Recovery of selenium by sublimation under oxidizing conditions, with the formation of the dioxide which condenses to a crystalline solid, has the advantage of separation and purification in one step. Extraction of selenium with sodium cyanide has the advantage that it can be applied direct to washed sludges, and the resulting solution when acidified deposits red, amorphous selenium. Many procedures have been examined in the search for satisfactory methods for the microdetermination of carbon, hydrogen and fluorine.

The Radiochemical Group has given special attention to the use of ion-exchange resins for the recovery of metals from solution, particularly the recovery of gold and associated metals from cyanide solution with 'Amberlite *IRA*-400'. Considerable improvements have been made in the chromatographic technique for the separation of niobium and tantalum, and details have been worked out for the determination of rhodium, platinum and palladium, using a paper-strip technique with a solvent mixture of methyl *iso*butyl ketone and hydrochloric acid. A study of the elution of nickel and copper with organic solvents from the cation-exchanger 'Zeocarb 225' showed that an analytical separation could be obtained using acetone containing a controlled amount of water and hydrochloric acid for the elution of copper.

In the Organic Group, purification work on large batches of hydrocarbons, cresols, xylenols and butidenes has been pressed further. In preliminary experiments on the zone-melting of naphthalene containing 0·2 per cent anthracene, the passage of eight zones reduced the anthracene content in half the charge to less than 1/10,000th of its original value. The critical temperature of acetylene has been determined as 35·18° C. by observations of the disappearance of the menisci in sealed tubes immersed in a water-bath. Some nine hundred infra-red spectra were measured during the year, as well as some thermodynamic properties of very dilute aqueous solutions of methylpyridines, ethylpyridines and pyridine at 25° and 40° by a transpiration technique in an attempt to establish why certain of these bases exhibit closed-loop solubility curves. Preliminary results indicate that 4-hydroxy*iso*phthalic acid is less toxic and more effective than aspirin, and at least as effective as aspirin, in counteracting fevers in rabbits caused by a preparation of pyrogen from *Proteus vulgaris*. A study of the reaction of phosgene with ethylene oxide has been extended to epichlorohydrin, propylene oxide, 2 : 3-epoxybutane (*trans*), styrene oxide, *cyclo*hexane oxide and di*iso*butylene oxide. Further derivatives of resorcinol have been investigated in relation to condensation polymerization with formaldehyde, and attempts made to introduce the arsenic acid group into a chloromethylated polystyrene, while the reaction of carbon monoxide with lithium aluminium hydride solutions has been reinvestigated using carbon-14 monoxide.

The High Polymers Group concentrated its attention on the same main themes as in 1953, and has made further progress in the investigation of the complexing behaviour of amphoteric resins based on cross-linked polystyrene. A bibliography has been prepared containing approximately four thousand references to the preparation, properties and applications of ion-exchange resins. Factors controlling the semi-permeability of polyvinyl alcohol membranes continued to be studied.

The Microbiological Group continued its fundamental studies on sulphate-reducing bacteria in four main directions: the intermediates formed during the oxidation of simple carbon compounds such as malate; a preliminary study of a polysaccharide formed by these bacteria; the function of their

cytochrome in the cell metabolism; and the concentration, purification and identification of various cell pigments. The bacterial cytochrome extracted from large quantities of acetone-dried cells appears to be quite distinct in properties from any cytochrome hitherto described. Studies on the breakdown of phthalic acid by a Gram-negative aerobic rod (NCIB 8334) isolated from an industrial percolating filter indicate that attack does not follow the degradative pathway via *cis-cis*-muconic acid described for several other aromatic compounds. Mutation studies have been started with this organism to obtain strains with a block in the metabolic pathway of phthalate oxidation.

BIOLOGICAL AND MICROBIOLOGICAL METHODS OF ESTIMATING VITAMIN B_{12}

A CONFERENCE on "Biological and Microbiological Methods of Estimating Vitamin B_{12}", organized by the Biological Methods Group of the Society for Analytical Chemistry, was held on May 13 in the lecture hall of the Royal Society for Tropical Medicine and Hygiene at Manson House, Portland Place, London. In his opening remarks, the chairman, Dr. L. J. Harris (Dunn Nutritional Laboratory, Cambridge), reviewed briefly the development of the present knowledge of vitamin B_{12}, from the discovery by Minot and Murphy in 1926 that pernicious anæmia could be controlled by the use of a liver preparation, to the isolation from liver of the curative principle—vitamin B_{12}—by two separate groups of workers, one in Britain and the other in the United States. In the United States the isolation was greatly speeded up by the application of a microbiological control technique, based on the finding that the clinical activity of liver preparations was closely paralleled by their activity for a strain of *Lactobacillus lactis*, which had been shown by Shorb to require an unidentified growth-factor present in liver. Both the *Lb. lactis* factor and the anti-pernicious anæmia principle were later identified with vitamin B_{12}.

During recent years, the *Lb. lactis* assay has been largely superseded by improved microbiological techniques, employing a variety of test micro-organisms. In addition, the biological techniques with chicks and rats have been developed and improved. All these different techniques are attended by the inevitable problems of specificity of test, and in some cases of completeness of extraction. Dr. Harris then posed the question: How far do the different methods of assay measure the same thing?

In the unavoidable absence of Mr. F. A. Robinson, his introductory paper was read by Mr. M. E. H. Fitzgerald (Allen and Hanbury, Ltd.). Mr. Fitzgerald pointed out the fundamental difficulties which can complicate the microbiological assay methods. The presence in natural materials of compounds closely related to vitamin B_{12}, inactive for higher animals and differently active for different test micro-organisms, can give misleading results. In some of the assays non-specific responses are caused by reducing substances, deoxyribosides or methionine. Then again, in some materials—milk and blood serum, for example—the vitamin is present in a bound form, unavailable to the test micro-organisms. Generally the vitamin can be liberated by heating or enzyme proteolysis in the presence of cyanide. But heating with cyanide does not in all instances release free cyanocobalamin. Mr. Fitzgerald pointed out that liver contains alkali-stable compounds that are active for the test micro-organisms, and among these may be an alkali-stable form of vitamin B_{12}.

A survey of published and unpublished values obtained for liver and liver extracts suggests the presence in them of a form of vitamin B_{12} active for *Lb. leichmannii* but not for *Escherichia coli*. Furthermore, it appears that neither organism responds to some clinically effective forms of vitamin B_{12}.

Dr. R. H. Girdwood (Department of Medicine, University of Edinburgh) considered the measurement of vitamin B_{12} in the blood serum, and described in some detail his technique of assay with *Lb. leichmannii*. By this method, normal values range between 130 and 750 $\mu\mu$gm. vitamin B_{12}/ml. Although to the clinician vitamin B_{12} deficiency is usually synonymous with megaloblastic anæmia, a low serum vitamin B_{12}-level may precede the development of anæmia. Dr. Girdwood suggested that probably the best way to measure serum vitamin B_{12}-levels is to use both the *Lb. leichmannii* and *Euglena gracilis* assays.

The next speaker, Dr. D. H. Shrimpton (Rowett Research Institute, Aberdeenshire), discussed the problems of measuring vitamin B_{12} in animal feeding-stuffs, using *Lb. leichmannii* and *Ochromonas malhamensis* as test micro-organisms. In general, enzymic extraction procedures are unnecessary, and may in fact introduce non-specific growth stimulants. Autoclaving the test material with water at *p*H 4·8 in the presence of a trace of cyanide is usually sufficient to liberate the vitamin quantitatively.

The *Lb. leichmannii* assay is subject to interference by deoxyribosides and by a variety of vitamin B_{12}-like compounds. In practice, in the tube assays, interference by deoxyribosides is only rarely encountered, except with materials very low in vitamin B_{12} and rich in nuclear material. Similarly the vitamin B_{12}-like compounds are of limited occurrence, being largely confined to natural materials that have been subjected to microbial fermentation.

Ochromonas malhamensis closely resembles the higher animals in the specificity of its requirement for vitamin B_{12}. But in practice the activity measured by micro-organisms is not necessarily a reliable prediction of the gross vitamin B_{12}-activity of feeding-stuffs for higher animals. In fact, the results of a comparison of chick and microbiological assays of a variety of feeding-stuffs indicate that, in general, the less specific micro-organism, *Lb. leichmannii*, approximates more closely to the findings by chick assay. This agreement is possibly fortuitous, but is nevertheless useful at the present stage of development of methods for assessing vitamin B_{12} activity.

Dr. Margaret E. Gregory (National Institute for Research in Dairying, University of Reading) described the measurement of vitamin B_{12} in milk. Three test micro-organisms—*Ochromonas malhamensis*, *Lb. leichmannii* and *Esch. coli*—give closely similar results when used for assaying the vitamin in the milk of several animal species. For routine use, *Lb. leichmannii* is preferred as test organism, largely because no shaking machine is needed with it. A further advantage is that with turbid extracts the growth responses can be measured titrimetrically.

Vitamin B_{12} occurs in milk, mainly as cobalamin, in protein-bound form. In cow's milk the vitamin can be liberated simply by diluting the milk with

water and heating at *p*H 4·8 in the presence of a trace of cyanide. In human and pig milk this simple procedure is inadequate, and it is necessary to liberate the vitamin by treatment with cyanide-activated papain.

In the next paper, Dr. Marie E. Coates (National Institute for Research in Dairying, University of Reading) discussed the biological techniques for the assay of vitamin B_{12}. It is generally necessary to deplete the reserves of the test animals, either by restricting the vitamin B_{12} intake of the dams or by the inclusion of stress factors in the diet. The chick is probably a more suitable test animal than the rat; but both are likely to over-estimate the potency of crude materials containing unidentified growth factors unrelated to vitamin B_{12}. The presence of vitamin B_{12}-like compounds does not greatly complicate the biological assays. Only the recently discovered vitamin B_{12III} is active, and that only to the extent of one-twentieth of the activity of vitamin B_{12}. Although biological assays give a measure of the physiological availability for the test species, there is evidence that some of the naturally occurring bound forms of the vitamin present in one species may be poorly utilized by animals of other species.

The final paper of the conference was read by Dr. W. R. Pitney (Postgraduate Medical School, London), who considered the assay of vitamin B_{12} in blood serum, using *Euglena gracilis* as test organism. The assay is very highly sensitive, and only small volumes of serum are required. It is probable that, with serum, *Euglena* is specific for vitamin B_{12}. Earlier reports of non-specific stimulants in occasional samples of serum may well have been due to contamination of glassware with vitamin B_{12}. Assays on 560 samples of serum have shown a coefficient of variation of 20 per cent, a degree of accuracy more than sufficient for clinical purposes.

Euglena assay shows that vitamin B_{12} in human serum is mostly bound to protein, and this finding is confirmed by dialysis and electrophoresis. Vitamin B_{12} in liver homogenates is assayed as 'free', but behaves on dialysis and electrophoresis as 'bound'. It is probable that vitamin B_{12} occurs in two bound forms in biological materials—a firmly bound form in serum in which the vitamin is unavailable to *Euglena* without preliminary heating, and a looser combination in tissues.

NON-DESTRUCTIVE TESTING GROUP OF THE INSTITUTE OF PHYSICS

SUMMER MEETING

THE summer meeting of the Non-Destructive Testing Group of the Institute of Physics was held during June 22–25 in the Royal Technical College, Glasgow. On the evening of the first day, Sir Andrew McCance gave an address in which he traced the progress made, in his lifetime, by the introduction of physical methods into industry, and he emphasized the increase in speed and accuracy which has been achieved by the establishment of non-destructive techniques. He directed attention to the fact that future progress in the testing of materials is dependent upon the systematic investigation of physical phenomena, and he exemplified his argument by reference to the study of damping capacity. Later during the meeting Sir Andrew arranged for members to visit the Lanarkshire Steel Company and the Dalzell Research Laboratory, both of which are at Motherwell.

The first paper of the meeting, by Mr. T. S. Wylie (Department of Natural Philosophy, Royal Technical College, Glasgow), dealt with the course of training in radiography which forms part, albeit a small part, of the four-year course in applied physics at the College. Mr. Wylie showed how great is the care needed in planning the training so as to provide adequate instruction and experience when the time allotted to radiography can be no more than that covered by ten lectures and forty hours of work in the laboratory. He reported on the analysis, which he has carried out, of the requirements for a course in radiography, and explained, by reference to a number of charts and tables, how he has established a course in which the progress of the lectures is closely integrated with the progress of the experimental work and from which all unnecessary detail has been eliminated. During his lecture, and again in the discussion which followed, Mr. Wylie stated that he had found lack of knowledge of foundry practice on the part of students one of the biggest handicaps in the study of radiography; he stressed the need for students to spend time working in a foundry.

The importance of radiography to the shipbuilder has long been recognized, and Mr. Duffy (Clyde Shipbuilders' Association) explained how, at the time of the change from the use of riveted joints to welded joints, the Clyde shipbuilders combined together to operate an organized district scheme for the radiographic inspection of welded structures. He described the way in which this scheme operates and gave details of the equipment which is made available by it for inspection purposes. Owing to the difficulty of moving around ships with large X-ray units, the use of isotope sources for site work is preferred; and in this connexion Mr. Duffy remarked that, because of the portability of isotopes, their use shows considerable economy over that of X-ray units, even though longer exposure times are required.

Mr. Duffy dealt with the precautions necessary to protect personnel from radiation and high-tension equipment on site inspection. He then directed attention to the impossibility of carrying out a one hundred per cent inspection of the welds on a ship, and stated that the main object of radiographic examination in shipbuilding is that of testing the welder rather than the weld. Radiography is best used as a test for control of weld quality, and nobody should be allowed to make a single weld on a ship before his ability has been assessed by radiographing test plates welded by him. Mr. Duffy concluded his paper by describing the types of defects found in welds and by showing how radiographic examination enables wrong welding procedures to be detected.

Although the capital expenditure involved in the purchase of industrial boilers is large, this expenditure is small compared with the cost of the fuel consumed by the boilers. Boilermakers are, therefore, always trying to increase the thermal efficiency of their products, and this is done by designing boilers to operate at higher temperatures and pressures. The paper by Mr. W. E. Marskell (Babcock and Wilcox, Ltd.) was therefore concerned with the establishment of a system of non-destructive testing which would ensure the safe working of boilers. He

emphasized the importance of radiography and gave examples of the use of X-rays and γ-rays. Much attention was given in the paper to the increasing use of ultrasonic testing, its appeal being attributed to its sensitivity to the detection of small defects, its cheapness and to the fact that by its use no precautions need to be taken for the protection of personnel. Mention was made of magnetic testing, particularly in connexion with the detection of subsurface faults in butt-welded pipes.

The lecture by Dr. R. W. B. Stephens (Imperial College of Science and Technology, London) was concerned with the physical principles underlying the establishment of non-destructive testing techniques. He confined his attention to surface properties and reviewed those properties which are, or could be, used as a means of detecting 'geometrical defects' (surface cracks and lack of flatness) and of studying the surface structure of materials. The difficulty of defining exactly what is meant by a surface was mentioned, and attention was directed to the care which must be exercised to ensure that the process of surface examination does not in itself involve a change in the conditions of the surface (for example, cutting sets up mechanical strains; polishing may destroy crystallinity). Dr. Stephens's treatment of his subject included a review of the optical properties of surfaces with reference to their application as a basis for the development of non-destructive testing methods; and an appraisal of the effectiveness, for the examination of surfaces, of magnetic and electrostatic fields, eddy currents, mechanical waves (Rayleigh waves), surface (electrical) resistance, heat flow, electron emission and spectroscopic examination.

Dr. D. Tabor (Department of Physical Chemistry, Cambridge) began his lecture on the physical meaning of indentation and scratch hardness by describing the nature and area of contact between two surfaces. He then went on to define 'hardness' as the resistance of a material to deformation and to describe the methods of measuring hardness. He showed that values of indentation hardness provide a measure of the plastic properties of materials and not of their elastic properties. By means of an elementary examination of stress–strain curves, he defined the term work-hardening index, and, with reference to the Vickers and the Brinell hardness, he derived the simple relationships between hardness and yield strength for materials which do, and do not, work-harden. Dr. Tabor then turned his attention to the subject of scratch hardness. He referred to the first scratch-hardness scale formulated in 1824 by the geologist Mohs, and he discussed the establishment of scratch-hardness scales as well as the conditions under which one surface will scratch another. He explained the fact that under high hydrostatic pressure brittle materials become ductile, and showed that the scratch hardness and the frictional behaviour of brittle materials are dependent upon their plastic properties and not upon their brittle properties.

Mr. H. L. Carson (British Welding Research Association) gave an assessment of ultrasonic techniques, with special reference to welds, in which he traced the development of weld inspection by ultrasonics. He made a critical survey of the methods of injecting ultrasonic beams into welded materials and paid particular attention to probe design, the coupling between the probe and material under inspection, the monitoring of the contact between the probe and the material by use of subsidiary crystals, and the choice of direction of the ultrasonic beam relative to the position and orientation of the weld. The value of the use of shear waves for weld inspection was emphasized and, with reference to particular cases, Mr. Carson showed when single probes and double probes should be used.

The problem of assessing the significance of defects was stated as presenting the greatest difficulty associated with ultrasonic inspection of welds. It is frequently not possible to decide whether the cathode-ray tube trace, showing the presence of a defect, is indicative of a serious defect or not. In this connexion, Mr. Carson pointed out the necessity for some form of instrument standardization and criticized the present standard test-block procedure which has been established for this purpose.

In their paper on problems in the interpretation of ultrasonic tests on steel, Mr. I. M. MacKenzie and Mr. R. Kennedy (Colvilles, Ltd., Motherwell) directed attention to the shortcomings of such tests as a means of inspecting steel. While they recognized the valuable contribution made to inspection by ultrasonic methods, they were able to point to many examples where ultrasonic tests have yielded erroneous indications and, although these examples were of an exceptional nature, it was easy to appreciate that the exceptions tend to undermine the confidence which the steel-maker must have in his testing procedure. Mr. MacKenzie and Mr. Kennedy left no doubt in the minds of the physicists in the audience that improvements in ultrasonic testing are essential and that these improvements can only be achieved by intensive effort on the part of physicists working in close collaboration with metallurgists and engineers.

Preliminary experimental work to determine the uses to which neutron radiography can be put is being carried out at the Atomic Energy Research Establishment, Harwell, and Dr. J. Thewlis and Mr. R. T. P. Derbyshire described the progress which has been made so far at the Establishment. An introductory account was given of the properties of thermal neutrons, from which it was seen that there are striking differences in the absorption, by materials, of X-rays and neutrons (for example, water has a high absorption coefficient for neutrons, whereas lead is relatively transparent to them), and, although the highly penetrating character of neutrons should make them suitable for radiography, their negligible photographic effect is a handicap to their use. The experimental work described was concerned mainly with the construction and performance of intermediate screens which have been devised for overcoming this difficulty, and a series of radiographs obtained with the apparatus described was shown with the object of illustrating the kind of application to which neutron radiography can be put. The most effective source of neutrons is a nuclear reactor; but Dr. Thewlis described a number of other sources which could be installed and used in industry if neutron radiography is ever required.

The final paper, by Dr. E. G. Stanford (Aluminium Laboratories, Ltd., Banbury), dealt with the scope of non-destructive testing. Tests are made on materials to check their dimensions, to detect the presence of defects and to determine their properties, and in his paper Dr. Stanford enumerated the tests devised for these purposes. Testing procedure involves the examination of specimens taken from a material or the examination, by non-destructive methods, of the material itself. Tests made on specimens may involve the destruction of the specimen, a change in the material of the specimen

without its shape being destroyed, or no change whatever in the specimen. The field of non-destructive testing should cover all tests except those in which the specimen is destroyed.

Engineers are usually obliged to attach most importance to those properties which are determined from tests in which the specimen is destroyed. This means that the actual material which goes into service is not tested. As advances take place in engineering design, and materials are required to operate under increasingly severe conditions, it is becoming essential to know that the material put into service has the properties quoted from tests on specimens taken from it. Non-destructive tests should therefore be developed which will give this information, and the means of establishing such tests will come by three lines of study: how those properties determined by non-destructive tests vary with the constitution and structure of materials; how these properties can be used to identify changes in constitution and structure; and how to relate changes in constitution and structure to those properties which are determined by destructive tests.

APPLICATIONS OF ULTRASONICS

CONFERENCE IN MARSEILLES

THERE have been a number of conferences on various aspects of ultrasonics during the past few years, and that held in Marseilles during May 23–28, under the auspices of the Centre National de Recherches Scientifiques, was devoted to applied ultrasonics, though some papers on fundamental aspects were also read. The conference was subdivided into four sections comprising physical, chemical and medicobiological applications and transducers. Most papers fell into the first and third divisions. Prof. F. Canac (66 rue St. Sebastian, Marseille), the organizer of the conference, expects to publish in a book all the papers presented, and they may also appear as a special volume of *Acustica*.

The scientific part of the meeting opened with an account of the pioneer work of Langevin and Florisson in the use of ultrasonics for underwater detection, recalled by Prof. F. Canac, and then Prof. A. Giacomini presented statistics of the different types of applications during the past twenty years. About fifty sectional lectures and papers were read, of which it is only possible here to mention those which involve recent applications in industry and the like.

R. G. Busnel and M. Degrois showed an interesting film of the actions produced in a liquid under pressure when small cavitation bubbles appear in the liquid and the familiar geyser rises from the free surface. At higher pressures the latter disappears, particularly when the pressure is diminishing, and the cavitation nuclei coalesce leaving a flat free surface. No explanation was offered for these experiments, and as only one frequency was tried it is not possible to determine whether resonant vibrations of the cavity bubbles are concerned.

Prof. E. Meyer showed some interesting experiments with ultrasonics in a large box, imitating on a small scale the distribution of the sound amplitude throughout an auditorium due to a steady audible source. It was possible, by varying the form of protuberances applied to a wall and by having the other walls either hard or absorbent, to study the diffusive properties of the box for the ultrasonics. Dr. E. G. Richardson gave an account of the incidence of ultrasonics in recent aeronautical research, dealing in particular with the high-frequency output of jet engines and relaxations in substitute vapours used in supersonic wind-tunnels. The former was also the theme of an investigation by Mlle. M. Merle, who used small jets in the laboratory.

L. Bergmann described an apparatus for quickly giving warning of the presence of an explosive mixture in a room, by the use of an ultrasonic interferometer, while C. Florisson and R. Esche and collaborators described apparatus for coagulating and generating, respectively, aerosols of fine dispersion; these are of importance in chemical industry and the practice of medicine. In the same field V. Gavreau described the development of ultrasonic whistles which can be applied to—among other things—the coagulation of smoke.

A considerable number of papers occupied the medical and biological section, mainly emanating from Germany, where this type of application is much developed. Applications of ultrasonics in this field ranged from the treatment of nervous diseases and cancer to promoting the germination of wheat and killing of bacteria. To some of these a specific effect of frequency (or of wave-length) was attributed; but in many applications, apart from the concentration of energy to be obtained, it seems that vibrations over quite a gamut of frequency can be effectively employed (this is also true of the formation of emulsions, as M. Degrois and his colleagues showed).

After thirty years of experience of ultrasonics in applied biology, it is not yet definite how far the effects are thermal and how far mechanical, but Dr. J. Stetler gave an interesting lecture on this problem, describing some careful experiments in which he sought to distinguish these two effects by using first continuous waves and then reiterated pulses of different lengths. In the fourth section, it is only possible to cite a lecture by C. F. Brockelsby, in which he gave many data for the development of magneto-striction generators of high power.

INSTITUTE FOR SCIENTIFIC RESEARCH IN CENTRAL AFRICA

REPORT FOR 1952

THE fifth annual report of the Institute for Scientific Research in Central Africa, Leopoldville, Belgian Congo, covering the year 1952 has recently been published*. Besides the administrative reports, among which that of the director, L. van den Berghe, gives a summary of the scientific work of the Institute during the year, it includes V. G. Dethier's paper on the biting response of tsetse flies, a bibliography of *Plasmodium berghei* by I. H. Vincke and M. Lips, an account by the director of the laboratories of the Institute at the Scientific Research Centre at Kivu, Lwiro, and a long account of the medical mycology of the Belgian Congo by R. Vanbreuseghem. A bibliography of papers published during the year by members of the Institute's staff or associated investigators is amplified by abstracts of the papers.

* Institut pour la Recherche Scientifique en Afrique Centrale (I.R.S.A.C.): Cinquième Rapport Annuel. Pp. 377. (From the Institute's Offices in Brussels, 1955.)

Among investigations in progress noted by the director in his report are an entomological inventory of the different natural regions as a prelude to a study of their fauna and a study of the entomological fauna of the remains of the primary forests still existing in Ruanda-Urundi; investigations on the cycle of trypanosomes; and studies of climatic and technical problems in tropical habitation. Other studies have related to the control of malaria among children in the plain of Ruzizi and the territory of Uvira, the transmission of trypanosomiasis by *Glossina brevipalpis* on the River Malagarasi, the use of electrophoretic diagrams in nutrition studies, such as in a case of kwashiorkor, morphometric studies of the lakes of Bulera, Luhondo, Mohasi, Mugesera, Bilala, Sake and Bugwero, in Ruandi, including also plankton studies and the study of the littoral fauna. Therapeutic studies of kwashiorkor, studies of the incidence of goitre in Ruanda, of the sensory physiology of the tsetse, a physico-chemical and hydrobiological study of Lake Gileppe, near Verviers, and of the variation with altitude of the potential gradient of the sun have also been made, and biochemical methods applied to the determination of proteins, protein fractions, lipids and cholesterol of blood.

Intraspecific variations among *Hyperolius viridiflavus* and *H. lateralis* have been studied in Ruanda and Urundi; *Schoutedenella mossooensis* sp. n. du Mosso, probably a new race of *Hyperolius cinnamomeoventri*, a Congo species encountered for the first time in Ruanda in the valley of the Akamyaru, was captured as well as three other species not previously captured in Ruanda-Urundi: *Atractaspis bibroni rostrata*, *Hyperolius oxyrhynchus* and *Schoutedenella lameerei*. An inventory and ecological study were made of some arthropods of the Great Lakes, and a study of the indigenous political organization of the kingdom of Ruanda was completed for presentation as a thesis. An inquiry into the migrations and biology of the fish of a river torrent in the Tanganyika basin, studies of the syncline of Itombwe between Lakes Kivu and Tanganyika and of the frequency of the sickle-cell trait, examination of anthropometric practices in Ruanda-Urundi, the prehistoric industry of the plain of the Lemba, anæmia in states of malnutrition and paludism in mammals and the invertebrate hosts are also noted, as well as the reorganization of the system of demographic inquiry in Ruanda-Urundi.

HOP PICKING BY MACHINE

SINCE the Second World War, shortage of labour for picking hops by hand has forced English growers in increasing numbers to turn to the use of picking machines. In 1947 it was estimated that not more than eight machines were in use; the figure had increased to more than a hundred machines in 1954 and a further hundred machines are on order for 1955. These machines are mainly large stationary types which are best suited to the needs of growers of larger acreages. Smaller machines are being produced for the smaller growers, so it is probable that within a few years English hops will be picked mainly by machine.

These developments have been kept under observation by the Department of Hop Research of Wye College, Kent. Each year from 1949 until 1953 inclusive, the Department, with encouragement and financial help from the Agricultural Research Council, has organized surveys of picking machines at work on the farms of commercial growers. The results of these surveys have been published in detail in the annual reports of the Department for the years 1950–53 inclusive. At the request of the Hops Marketing Board, the findings of the surveys have been summarized in an article by G. P. Chater and Miss C. L. Jary*.

The main point emerging from the surveys is the importance of intelligent and efficient management; the best of picking machines will give poor results if badly managed.

The concept of machine picking as a factory process is a valid one. From plant to pocket the hops pass along a production line, and, as in all mechanized industries, good management based on a clear understanding of the process as a whole is essential if a good final sample of dried hops is to be produced.

The chief disadvantage of all picking machines is the amount of breakage they cause to the hop cones. Such breakage makes for difficulties in subsequent cleaning and drying and may lead to wastage of hop material in general and of resins in particular. The subject of resin-loss is a controversial one. An investigation is nearing completion at Wye in which a series of forty-two pairs of pocket samples from the 1954 crop is being examined. Each pair consists of hops of the same variety and from the same farm, one sample of each pair being hand picked and the other machine picked. Preliminary results show that in thirty-five of the forty-two pairs of samples the hand-picked hops appear to have more resin than the machine-picked ones; in the remaining seven pairs the machine-picked hops appear to have a higher resin content than the hand-picked samples.

One of the most important objects of future research on machine picking must be to reduce damage to the cones. In addition to preventing wastage and improving drying performance, such reduction in the breakage of cones would reduce the risk of resin-loss. Future research in England may also have to pay attention to the cleaning of machine-picked hops. In the United States, picking machines have been in general use for some ten years and more than 90 per cent of the crop there is now picked by machine. American growers are now producing by machine-picking large quantities of dried hops with less than 2 per cent by weight of leaf and stem. Data collected in the Wye College surveys suggest that English machine-picked hops have from 3 per cent to 12 per cent of leaf and stem and that hand-picked hops have 3–6 per cent; such information is too scanty to permit of large generalizations. It is possible, moreover, that the relative cleanness of American machine-picked hops is achieved by tolerating a degree of wastage of broken hops that could not be accepted at present in England. This aspect of machine picking would appear to merit investigation.

In the Wye College surveys the approach was that of the hop grower rather than that of the agricultural engineer. This approach was the only one permitted by the circumstances and has yielded valuable results. It has, however, obvious limitations, and the time has come for research on picking machines, and on the related problem of the drying of machine-picked hops, to be taken up by a team of agricultural engineers.

If research on the machine becomes the responsibility of the agricultural engineer, the growing of

* Obtainable from the Secretary, Wye College, Ashford, Kent. 1s.

hops for the machine remains the responsibility of the hop grower.

The correct interpretation of the results of all this work demands more knowledge of how the hop plant grows than is at present available. It is hoped that it may soon be found possible to appoint a plant physiologist at Wye College to make a detailed study of the pattern of growth of the hop plant.

THE HANDICAPPED CHILD

IN a school population of approximately 5,970,000 in England and Wales, 16,719 were pupils known to school medical officers to be physically handicapped. The most frequently recorded conditions responsible for the handicap included heart disease (4,453), cerebral palsy (2,954), deformities and amputations of the limbs (2,053), poliomyelitis (2,001), tuberculosis (1,766) and spina bifida (543). It is estimated that only about one child in every thousand is too severely handicapped to become entirely self-supporting and to be able to live a full life. The increasing emphasis of recent years upon the advisability of keeping such children at home has added considerably to the responsibility involved in the care of these children. It is not only in the case of the deaf child that there is often more than one patient. Indeed, there are often three, for both parents as well as the child have to be considered. No handicapped child can achieve the optimum enjoyment of life unless the parents are prepared to carry out to the full the instructions of their medical advisers.

The family doctor's responsibility in dealing with these unfortunate children is threefold. In the first place he must be on the look-out for any handicap so that he can detect it at the earliest possible age and refer the child to a specialist for advice as to what can be done to overcome, or at least ameliorate, the disability. Secondly, he must know of the organizations, voluntary and statutory, which are available to help such children. Thirdly, there is the supervision and care of the child in the home.

All these aspects are dealt with in a remarkably good issue of *The Practitioner* (**174**, No. 1042; April 1955), which includes articles by specialists on children's disabilities.

BREEDING BEHAVIOUR OF THE AMERICAN COOT

SOME peculiarities in the breeding behaviour of the American coot (*Fulica americans*) have been described by G. W. Gullion (*Auk*, **71**; October 1954).

The bird is probably always monogamous in its sexual behaviour. If one mate disappears during the nesting season, a second mate may be accepted within forty-eight hours. Among the resident coots with secure territories, pairing seems to be as permanent as the life of the birds or their ability to maintain a territory.

Coots breed in a habitat which contains abundant nesting material, and they use this material freely in constructing floating structures associated with breeding. These structures are bulky, and since materials seldom present a procurement problem, they are not built for permanence but must be added to repeatedly while in use. Eggs are seldom laid in more than two of the eight or nine structures which are usually built. The other structures are utilized for resting, roosting and brooding sites.

Three types of structures built by coots—a display platform, the egg nest and a brood nest—follow one another in a definite sequence, and breeding events can be reliably predicted by their appearance. Certain modes of construction permit the identification of a nest type even before it is placed in use.

Copulation normally, perhaps always, takes place on a display platform. There is little or no pre-copulatory display or chase, and the two birds resume normal activity within two or three minutes following copulation. Eggs may appear before the nest is completed and are laid daily in the very early hours of the morning. The nest is completed and lined by the time the clutch is complete.

Incubation is continuous and is shared by both sexes, the male probably doing the greater share of it.

When deposition of the clutch is just beginning the female incubates all night, but otherwise the male incubates from dusk to dawn; the female always takes about a four-hour shift at dawn and then shifts of about one-hour duration follow until sunset. Young coots are quite helpless until a day or so old and require prolonged parental care. The male parent does most of the brooding during the staggered hatching period, while the female brings food to the nestlings and takes the older ones away to feed and brood. Later, the parents divide the brood during feeding and brooding.

CHLOROPLAST STRUCTURE

IN a study of the structure and swelling properties of the chloroplasts of *Nitella cristata*, F. V. Mercer, A. J. Hodge, A. B. Hope and J. D. McLean have made some new and interesting observations and stated some tentative conclusions (*Austral. J. Biol. Sci.*, **8**, 1, 1; 1955). Electron-microscope studies of ultra-thin sections have shown that the normal chloroplast consists of about 40–100 lamellæ *c.* 70 A. apart, enclosed by an external membrane *c.* 70 A. thickness. Grana do not occur. The space within the chloroplast not occupied by the lamellæ is filled with a granular material resembling the cytoplasm. The chloroplast often contains a considerable number of osmiophilic globules *c.* 0·1μ in diameter lying between the lamellæ, their staining reaction with osmic acid indicating that they are probably lipoidal.

Numerous small osmiophilic bodies *c.* 100 A. or less in diameter are associated with the lamellæ. Starch grains, when present, occur between the lamellæ and appear to be enclosed within by a membrane. During swelling in hypotonic solutions, chloroplasts change in shape from disk to sphere to cylinder. Swelling results from the formation of vacuoles between the external membrane and the rest of the chloroplast (blebs), by increase in interlamellar spacing and by the formation of vacuoles between the lamellæ. The interlamellar vacuoles form by the lamellæ rounding up and coalescing to enclose the granular interlamellar material. Quantitative results for the volume : osmotic pressure relations, the volume : *p*H relations, the surface charge, and the apparent free space for potassium chloride show that swelling is an osmotic process. The osmotic gradients arise from (*a*) a Donnan system associated with the interlamellar material, and (*b*) from diffusible solutes present in the interlamellar solution. The high values for the apparent free space and the volume : *p*H

relations indicate that the chloroplast membrane is differentially permeable, not semi-permeable. The degree of swelling of chloroplasts in solutions is controlled by the osmotic pressure and *p*H of the solution, the differential permeability of the chloroplast membrane and lamellæ, and the cohesive forces maintaining the structure of the membrane and lamellæ. By analogy, it is suggested that the mechanism controlling the water relations of mitochondria, which also possess lamellar structures bounded by a thin membrane, may be similar to that of the chloroplasts.

POTASSIUM–ARGON AGES OF SOME LEWISIAN AND FENNOSCANDIAN PEGMATITES

By Prof. ARTHUR HOLMES, F.R.S.
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THE apparent ages, determined by the potassium–argon method, of ten samples collected from pegmatites, varying in composition from potash-rich granite to practically pure potash-feldspar, are presented in Table 1. Omitting three 'ages' which fall below 1,000 million years, for reasons stated below, the average age of the Lewisian pegmatites investigated is 1,090 ± 70 million years. Microcline from the Arendal district of southern Norway has nearly the same age, whereas a Svecofennian pegmatite in Finland is found to be about 1,800 million years old.

The age of each specimen, t, was calculated from the equation

$$t = \frac{1}{(1+R)\lambda_\beta} \cdot \ln\left(1 + \frac{1+R}{R} \cdot \frac{^{40}\mathrm{A}}{^{40}\mathrm{K}}\right) \text{years},$$

which, on substituting the data here adopted, becomes

$$t = 4{\cdot}202 \log_{10}(1 + 12{\cdot}24\ ^{40}\mathrm{A}/^{40}\mathrm{K}) \times 10^9 \text{ years}.$$

R is the branching ratio, defined as the ratio of the rate of orbital electron capture to the rate of β-emission. For R two values have recently been published, 0·089 ± 0·003[1] and 0·085 ± 0·005[2]. The first value is adopted here because it has been further substantiated by recent work at the University of Toronto upon nine samples of potassium minerals from pegmatites already dated by accompanying uranium minerals and ranging in age from 330 to 2,600 m.y.

For λ_β, the transformation constant for β-emission, a value of 0·503 × 10^{-9} y.$^{-1}$ has been obtained from eleven of the most recent counting experiments[3].

^{40}A is the mass of radiogenic argon-40 present per gram of sample as determined by a procedure which has already been described[3]. At least two determinations were made on all samples except 1159-*A*. All argon samples were analysed by a mass spectrometer. In no case did the abundance of argon-36 indicate the presence of more than 8 per cent atmospheric argon. Corrections were made for this; but even the largest correction lowered the resulting age by only 2 per cent. The uncertainty shown is the standard deviation of individual measurements.

^{40}K is the mass of potassium-40 per gram of sample. It was calculated from potash analyses by adopting Nier's value for the isotopic abundances of potassium[4]. Reuterswärd[5] has obtained a value for the abundance of potassium-40 that agrees to within 1 per cent with Nier's result. At least two analyses were made for all the Scottish samples. The analysts were W. H. Herdsman (Glasgow), who used a gravimetric method; and the Chemical Research Laboratory, Teddington, W. R. Inman (Canadian Bureau of Mines, Ottawa) and K. Watson (University of Toronto), who used flame photometers. The ages were calculated from the mean values. The Norwegian sample was analysed by W. R. Inman and W. H. Herdsman, and the Finnish samples by H. B. Wiik (Geological Survey of Finland).

The experimental results are listed in Table 1. The limits of uncertainty given for the ages are based upon an estimated mean probable error of 10 per cent in the value of ^{40}A/^{40}K, which in all cases is greater than the combined error due to the argon and potassium determinations.

1243-*A*. White perthitic microcline, with sporadic inclusions of quartz, collected by Mr. Martin Kürsten from a 16-ft. wide pegmatite trending east-north-east across the anorthosite of the eastern slopes of Roneval, South Harris. The rocks of this region have been described by Jehu and Craig[6], the petrology and geological history by Davidson[7], and the pegmatites, as sources of alkali feldspar, by Robertson[8].

1244-*A*. Pink perthitic microcline with irregular streaks of quartz and muscovite, collected by Dr. R. M. Craig[6] from the north-east-trending Northton pegmatite near Chaipaval, South Harris. For detailed description and maps see Robertson[8].

1159-*A*. Pink perthitic microcline, with inclusions of quartz and streaks of sericite, collected by Dr. R. M. Craig[9] from a north-east-trending pegmatite on the islet of Shillay in the Sound of Harris, about six miles west of the south-west coast of South Harris. The locality is shown at the extreme top of Plate IV of Jehu and Craig's paper[9].

1173-*A* and 1242-*A*. These were specimens from a collection made by Dr. R. Campbell[10] from a pegmatite north of Rhiconich, extending west-north-west from Cnoc an Tuir towards the north-east shore of Loch Inchard. The locality is in west Sutherland, about 13 miles south of Cape Wrath, and is shown on Fig. 6 of Robertson's report[8], on p. 12 of which the pegmatite is fully described. Although the original specimens looked much alike and consisted of pink microcline, buff albite-oligoclase, quartz and micas, microscopic examination revealed that, whereas the second was almost ideally fresh, the first was richer in quartz and had been intensely altered by sericitization, chloritization and introduction of ferruginous matter along cracks, cleavages and intergranular boundaries. Since such alteration would inevitably promote leakage of argon, the relatively low age yielded by 1173-*A* is not surprising.

1160-*A*. Pink perthitic microcline with inclusions of quartz, collected by Prof. D. B. McIntyre from a 100-ft. wide pegmatite at Badcall Quay, about a mile north-west of Laxford Bridge at the head of Loch

Table 1

Toronto No.	Locality	Radiogenic ^{40}A % by wt. $\times 10^5$	No. of runs	K_2O % by wt.	K_2O analyst	$\frac{^{40}A}{^{40}K}$	Apparent age (m.y.)
	Outer Hebrides (Lewisian)						
1243-*A*	Roneval, South Harris	9·12 ± 0·06	2	12·5 ± 0·1 13·02 ± 0·16 12·77	Watson Inman C. R. L.	0·0707	1,140 ± 70
1244-*A*	Chaipaval, South Harris	7·87 ± 0·04	4	11·7 ± 0·4 11·02	Inman Herdsman	0·0682	1,110 ± 70
1159-*A*	Shillay, Sound of Harris	6·70	1	10·2 ± 0·4 10·45	Watson Herdsman	0·0643	1,060 ± 70
	N.W. Sutherland (Lewisian)						
1173-*A*	N. of Rhiconich, Loch Inchard	3·01 ± 0·06	2	5·38 ± 0·02 5·52 ± 0·13	Watson Inman	0·0546	930 ± 70
1242-*A*	N. of Rhiconich, Loch Inchard	6·73 ± 0·06	2	9·88 ± 0·07 10·22	Watson C. R. L.	0·0664	1,090 ± 70
1160-*A*	Badcall Quay, Loch Laxford	6·29 ± 0·10	2	9·7 ± 0·3 9·66	Watson Herdsman	0·0643	1,060 ± 70
1250-*A*	Geodh' Eanruig, W.S.W. of Scourie Hotel	6·00 ± 0·16	3	12·32 ± 0·1 11·21	Inman Herdsman	0·0506	880 ± 60
1251-*A*	Cnoc an Fhir Bhreige, S. of Scourie	4·73 ± 0·14	3	11·09 ± 0·1 9·93	Inman Herdsman	0·0445	800 ± 60
1174-*A*	Arendal District, Southern Norway S. of Langesundfjord	7·55 ± 0·05	2	12·62 12·02	Inman Herdsman	0·0607	1,020 ± 70
1149-*A* to 1153-*A*	South-west Finland (Svecofennian) Varala Quarry, Kangasala	15·3 ± 0·3	6	11·06 ± 0·1	Wilk	0·138	1,810 ± 120

Laxford. The locality is *G*, Fig. 6, of Robertson's report[8].

1250-*A*. Perthitic orthoclase, somewhat sheared and showing undulose extinction, collected by Dr. J. Sutton and Dr. Janet Watson from a north-west-trending pegmatite at Geodh' Eanruig, about a mile west-south-west of Scourie Hotel and 5½ miles south-west of Badcall Quay. The relatively low argon content of this specimen may possibly be due to the heating effect of a thin basic dyke of unknown age which cuts the pegmatite.

1251-*A*. Perthitic microcline collected by Dr. J. Sutton and Dr. Janet Watson from a north-west-trending pegmatite about 500 yards west of Cnoc an Fhir Bhreige (west of Badcall village and two miles south of Scourie). This and the two foregoing pegmatites are mapped on Plate XX of Sutton and Watson's paper[11]. The low age found for 1251-*A* may perhaps be accounted for in the same way as that of 1250-*A*, as Dr. Sutton informs us that a dolerite dyke of unknown age is seen very close to the pegmatite and appears to cut across it.

Excluding the three samples from which loss of argon is suspected, the average age found is about 1,090 ± 70 m.y. So far, the only European age determinations of this order are those dating the pegmatites of the Arendal district of Norway, extending north-east–south-west from Langesundfjord to Kristiansand, where the geological sequence has a general resemblance to that of Harris, as indicated in Table 2. The Cape Wrath to Scourie sequence is also similar, save for the intervention of a suite of north-west dykes which has enabled Sutton and Watson[11] to establish the existence of two sets of structures and metamorphisms in the Lewisian rocks, distinguished as 'Scourian' and 'Laxfordian'. For this reason it cannot yet be regarded as certain that Scourian rocks are represented in the Harris and Arendal successions, as Table 2 suggests. The dated pegmatites, however, all appear to be late Laxfordian.

1174-*A* is a massive pink microcline (Currie Collection, Grant Institute) from a pegmatite of the Arendal suite, south of Langesundfjord. The age obtained, 1,020 ± 70 m.y., agrees within the limits of error both with the Lewisian ages here recorded and with the isotopic age (lead method) of 1,090 m.y. given by Nier[12] for one of the many cleveites from the Arendal district analysed by Mme. E. Gleditsch. This very important check suggests that the Laxfordian and Arendal orogenies were at least approximately contemporaneous. The Grenville pegmatites in Canada are also of about the same age, and here, too, they have been consistently dated by both uranium and potassium minerals[2,13].

Until recently, the Arendal district was regarded as part of the Svecofennian orogenic belt (Bugge[14]), and the age, 1,090 m.y., was thought to be representative for the late pegmatites of that belt, particularly as some of the uncorrected chemical ages of radioactive minerals from southern Finland had been found to be of the same order (Lokka[15]). It was therefore a surprise when the argon method applied to some potash feldspars collected by Dr. A. Kahma from the Varala pegmatite, about 30 km. east-south-east of Tampere in south-west Finland, yielded an age of 1,810 ± 120 m.y. Shortly afterwards, however, Parwell and Wickman[16] announced a number of uncorrected chemical ages, varying from 1,700 to 1,810 m.y., for uranium-bearing minerals from late Svecofennian pegmatites in the neighbourhood of Stockholm. Isotopic analyses of the respective leads

Table 2

South Harris (ref. 7)	Cape Wrath—Scourie (ref. 11)	Arendal, Norway (ref. 12)
—	Late granite (Laxford)	Late granite (Grimstad)
Pegmatites	Pegmatites	Pegmatites
Foliated granites (to N.)	Laxfordian foliated granites	Synkinematic granites
Migmatization	Laxfordian metamorphism and granitization	
—	Intrusion of N.W. basic dykes	—
High-grade metamorphism—	Scourian metamorphism—	High-grade metamorphism—
migmatites, charnockites and eclogites	migmatites and charnockites	arendalites (migmatic charnockites)
Anorthosite-norite and ultrabasic intrusions	Basic and ultrabasic intrusions	Hyperitic intrusions
Meta-sedimentary series	Meta-sedimentary series	Meta-sedimentary series

are in progress; but meanwhile the above convergence of evidence suggests that the Svecofennian pegmatites are very much older than those of the Arendal, Lewisian and Grenville provinces.

Apart from some of the potash determinations, the experimental results recorded in Table 1 were carried out at the University of Toronto with equipment for which grants were received from the National Research Council, Geological Survey of Canada, Research Council of Ontario and Imperial Oil, Ltd. We are indebted to Dr. G. L. Cumming and Dr. R. D. Russell, who made the mass spectrometer analyses; to Mr. K. Watson, Mr. W. R. Inman, Mr. H. B. Wiik and the Chemical Research Laboratory for potash analyses; and to the Carnegie Trust for the Universities of Scotland for a grant from which the cost of the Herdsman potash analyses was defrayed. Most of the specimens were specially collected for this investigation, and our thanks are extended to the various geologists who have co-operated in this joint enterprise.

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A CORRELATION BETWEEN THE RATES OF UNIMOLECULAR PYROLYSIS OF ALKYL HALIDES IN THE GASEOUS PHASE AND S_N1 RATES IN SOLUTION

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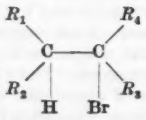
IT has been found that for molecules of the type



the major factor determining the rate of unimolecular dehydrobromination is the environment of the C—Br bond. The following relative rates (Table 1*a*) and activation energies (Table 1*b*) for a series of bromides in which the C—Br and C—H bonds range from primary to secondary to tertiary amply demonstrate this fact.

Table 1*a*

C—H	C—Br		
	p	*s*	*t*
p	1 (ref. 1)	170 (ref. 4)	32,000 (ref. 6)
s	3·5 (ref. 2)	380 (ref. 5)	46,000 (ref. 7)
t	6·3 (ref. 3)	—	130,000 (ref. 8)

Table 1*b*

C—H	C—Br		
	p	*s*	*t*
p	53·9	47·8	42·2
s	50·7	43·8	40·5
t	50·4	—	39·0

In Table 1*a*, the rates are given relative to ethyl bromide (taken as 1) at 380° C., and Table 1*b* shows the corresponding activation energies (in kcal.). The small effect of variations in the C—H bond type is shown again by the work of one of us (P. J. T.) on 4-bromo-pentene-1, for which, despite the allylic weakening of the C—H bond concerned in the elimination, the rate is comparable to that of *sec*-butyl bromide.

That no simple relationship exists between the activation energy for the elimination of H*X* (E_{HX}) and the homolytic bond dissociation energy $D(R–X)$ is shown in Table 2.

Table 2

	C_2H_5Br	*sec*-C_3H_7Br	*tert*-C_4H_9Br
$E_{H\text{-}Br}$	53·9	47·8	42·2
$D(R\text{-}Br)$ (ref. 12)	67·2	67·6	63·8
$D(R^+Br^-)$ (ref. 13)	183·7	156·3	140·3
Rate ratio	1	170	32,000
	C_2H_5Cl	*sec*-C_3H_7Cl	*tert*-C_4H_9Cl
$E_{H\text{-}Cl}$	60·8 (ref. 9)	50·5 (ref. 10)	41·4 (ref. 11)
$D(R\text{-}Cl)$ (ref. 12)	80·9	82·2	78·3
$D(R^+Cl^-)$ (ref. 13)	192·8	166·3	150·2
Rate ratio	1	178	19,500

Also included are the heterolytic bond dissociation energies $D(R^+X^-)$, that is, those for the process

$$RX \rightarrow R^+ + X^-$$

in the gaseous phase. These latter two sets of figures when compared with the rates relative to the ethyl compounds or the activation energies allow two conclusions to be drawn. The first is that a common mechanism is involved in the dehydrohalogenation of the bromides and of the chlorides. The second is that, while there is no correlation between the energies or free energies of activation and the homolytic bond dissociation energies, there is a clear correlation with the heterolytic bond dissociation energies.

A possible explanation of the strong dependence of the rate upon the nature of the carbon atom of the C—*X* bond lies in the assumption that activation consists primarily of an elongation with polarization of the C—Br bond with some assistance from a polarized C—H bond. That homolytic C—H fission is not part of the rate-determining process is shown by the observation that 4-bromo-pentene-1 decomposes at about the same rate as *sec*-butyl bromide, despite the fact that a β-allylic hydrogen atom is

involved and that a conjugated pentadiene is formed in the reaction.

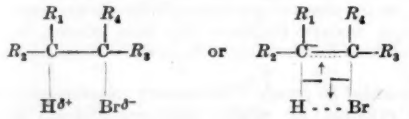
The polybromo ethanes form another interesting series of compounds. Thus it has been established by P. T. Good (unpublished work) that whereas ethylidene bromide decomposes faster than ethyl bromide, with ethylene dibromide the reverse is true. Partial confirmation of this behaviour is given by the work of Barton and Howlett[9], who observed that the rate of decomposition of ethylidene chloride is greater than that of ethyl chloride. Further halogen substitution on an α-carbon atom increases the rate, whereas such substitution on a β-carbon atom decreases it.

Thus, the following rate relationships have been observed for the elimination of hydrogen bromide:

$$(CH_3)_3C.Br > (CH_3)_2CHBr > CH_3CH_2.Br$$
$$CH_3CHBr_2 > CH_3CH_2Br > CH_2Br.CH_2Br$$

The first is well known to be the order characteristic of S_N1 or $E1$ rates in solution, and the second is the theoretical order, not yet verified, for unimolecular rates in a polar solvent. A qualitative analogy thus exists between S_N1 or $E1$ rates in solution and the unimolecular rate of elimination of hydrogen bromide. The behaviour of the first series with respect to the S_N1 and $E1$ mechanism has been explained in terms of the electron-releasing power of the methyl groups attached to the α-carbon atom which facilitates the formation of Br^-. The role of the polar solvent in such a mechanism is essentially the stabilization of the highly polar transition state.

It is now suggested that the β-hydrogen atom in the unimolecular elimination mechanism plays somewhat the same part as the solvent in the S_N1 and $E1$ mechanisms of reactions in solution. Thus the transition state may be represented by:



the β-hydrogen atom stabilizing the potential Br^-, just as the solvent does in solution. The situation may be represented graphically, as in Fig. 1. Curve (*a*) represents the potential energy for dissociation into R^+ and Br^-, from an excited electronic state; curve (*b*), the dissociation into atoms from the ground state. Curve (*c*) represents the hypothetical stabilization of the C^+Br^- system by the β-hydrogen atom, leading eventually to an olefin and hydrogen bromide. As a result of the intersection of curves (*b*) and (*c*), a splitting will occur, leading in particular to curve (*d*), which represents the reaction path.

Further confirmation of the views advanced here comes from qualitative observations on the system $CH_3OCHClCH_3$. This substance[14] undergoes reaction under S_N1 conditions more rapidly than *tert*-butyl chloride by a factor of at least 10^5. In the gas phase, decomposition sets in some 50° lower than for *tert*-butyl chloride.

It is suggested that the ideas developed here may be applied to other gas-phase eliminations. Although only *tert*-butyl and *tert*-amyl alcohols[15] have so far been investigated, it is interesting to note that Brearley, Kistiakowsky and Stauffer observed that, for both the chlorides and the alcohols, the ratio of the rates of the *tert*-amyl to that of the *tert*-butyl

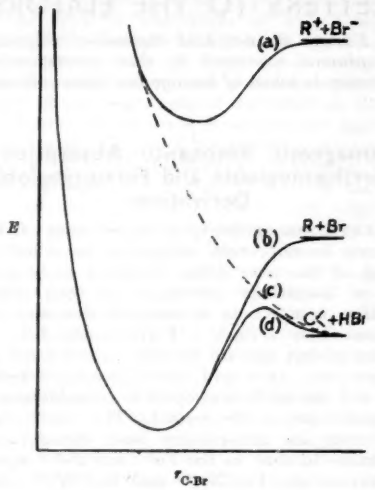


Fig. 1

compound was 2·35. In the case of the bromides, the ratio in the range of temperatures experimentally studied (~ 250° C.) was 2·34. The close agreement in the three cases is strongly suggestive of a common mechanism. Further, at 25° C., in '80 per cent' aqueous ethanol, the observed ratios of first-order constants (*tert*-amyl/*tert*-butyl) are for the chlorides 1·76; bromides, 1·57; and iodides, 1·93[16]. This provides additional evidence of the analogy between the S_N1 and $E1$ mechanism and the unimolecular elimination of hydrogen chloride and hydrogen bromide. Although the position with respect to the iodides is far from clear, the results are capable of interpretation on the basis of competitive mechanisms, one involving the fission of the C—I bond, the other involving elimination of hydrogen iodide.

Our present conclusion from this work, which is being extended, is that important modification is needed in the current view that all gas reactions are in principle homolytic, and accordingly require concepts of mechanisms and of structural effects which are strongly differentiated from those applying to heterolytic reactions in polar solvents.

We wish to thank Profs. E. D. Hughes and C. K. Ingold, and Dr. P. B. de la Mare and Mr. C. A. Vernon for many helpful discussions. We also acknowledge with thanks the communication of results, prior to publication, by Mr. P. T. Good.

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LETTERS TO THE EDITORS

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Paramagnetic Resonance Absorption of Ferrihæmoglobin and Ferrimyoglobin Derivatives

Magnetic susceptibility measurements on ferrous and ferric hæmoprotein complexes have led to the bonding of the iron being classified as 'essentially ionic' or 'essentially covalent', as with other co-ordination compounds containing elements of the first transition series[1]. Ferrohæmoglobin, acidic ferrihæmoglobin and its fluoride complex are in the first category, oxy- and carbonmonoxy-ferrohæmoglobin and the azide and cyanide complexes of ferrihæmoglobin are in the second. The electronic state of the iron has accordingly been thought strictly comparable to that in the Fe^{2+} and Fe^{3+} aquo-ions and that in the $Fe(CN)_6^{4-}$ and $Fe(CN)_6^{3-}$ complex ions respectively, since the corresponding magnetic susceptibilities are very similar.

Another manifestation of the magnetic properties is revealed by paramagnetic resonance absorption measurements from which g-values may be obtained, quantities related to the magnetic moment, the magnitudes of which for a compound of a first transition element depend not only upon the quantum number S but also the total orbital quantum number L and the symmetry around the ion. The ferric ion, which is in an orbitally singlet state ($L = 0$), has[2] one g-value of 2·0. Acidic ferrihæmoglobin and its fluoride complex, in which the iron has hitherto been assumed to be bound by essentially ionic bonds on the basis of paramagnetic susceptibility measurements, were therefore expected also to have g-values of 2·0. Using wet solid specimens, measurements at liquid-air and liquid-hydrogen temperatures have, however, given identical g-values of $5{\cdot}90 \pm 0{\cdot}05$ for both derivatives; these are very similar to that obtained for hæmin[3].

Since the observation of such high g-values in polycrystalline specimens was quite unexpected, the measurements were repeated at as many frequencies as possible in order to check that zero-field splitting was not responsible for the position of the line. Determinations were made at 3·2 cm., 1·25 cm., 1·0 cm., 8 mm. and 6 mm. wave-lengths, and the results are summarized in Fig. 1. The fact that all the points for both hæmin and acidic ferrihæmoglobin lie on straight lines passing through the origin show conclusively that true g-values are being measured. A slight asymmetry in the shape of the line was noted which indicates that the g-value spreads to somewhat lower values; but from intensity considerations this variation would appear to be small. It is hoped to carry out measurements on single crystals to obtain the precise values for the variation. It is quite clear, however, that the electronic state of the iron is entirely different in these 'ionic' complexes from that of the gaseous or aquated Fe^{2+} ion.

Measurements have also been made on the azide and cyanide complexes of ferrihæmoglobin, in which the bonding of the iron is classified as essentially covalent. A well-defined variation of g-value from 2·2 to 2·8 was obtained for the former, but the latter gave very weak absorption. No measurements have yet been made in the range $g < 2$, but the results for the azide complex show that there is a significant quantitative difference between a 'covalent' hæmoprotein complex and a 'covalent' inorganic co-ordination complex such as the ferricyanide ion, which has g-values[4] along the three axes of 0·94, 2·18 and 2·30.

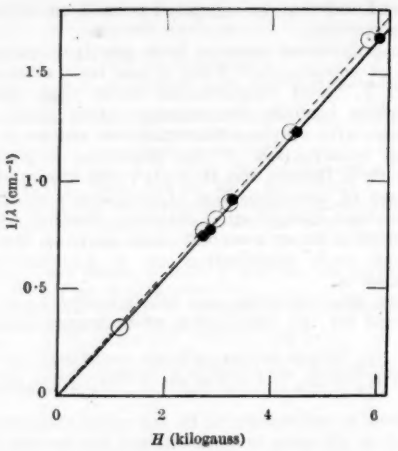

Fig. 1. Plots of reciprocal wave-length against magnetic field for hæmin (ref. 3) (open circles) and acidic metmyoglobin (full circles), from which g-values of $6{\cdot}00 \pm 0{\cdot}05$ and $5{\cdot}90 \pm 0{\cdot}05$ respectively have been obtained

Very similar absorption was observed for the corresponding ferrimyoglobin derivatives, and identical g-values were obtained. These results show, in a more direct manner than the magnetic susceptibility values, that no appreciable intramolecular interaction, in the sense of a coupling between the magnetic moments, occurs between the iron atoms in the recrystallized ferrihæmoglobin used for these measurements.

Note added in proof. Preliminary measurements on single crystals of acidic ferrihæmoglobin, kindly supplied by Dr. V. Ingram, of the Cavendish Laboratory, indicate that the high g-value of about 6 corresponds to $g_\perp$, that is, in the plane of the hæm. The asymmetry of the line reported above is due to a $g_{//}$ value, that is, along the axis perpendicular to the hæm, of less than 3, probably about 2·5.

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Anomalous X-Ray Scattering at Wave-lengths far from an Absorption Edge

It has been predicted recently[1] that the anomalous scattering of X-rays found close to an absorption edge would make direct Fourier synthesis methods applicable to non-centrosymmetrical crystals. In this procedure isomorphous substitution would be utilized for the determination of the absolute values of the phase angles of the scattered radiation; the phase angles are simply calculated from the structure factor triangle with sides F_1, F_2 and $F_1 - F_2$, where F_1 and F_2 denote the structure factors of the two isomorphous compounds while $F_1 - F_2$ is the difference in contribution of the heavy and light atom. The signs of the phase angles should then in principle be determinable from the effect of anomalous scattering on the intensities.

In the course of experiments designed to test the usefulness of the above scheme, the very interesting observation has been made that anomalous scattering effects can be observed at wave-lengths far from the absorption edges of any heavy atom in the crystal. The amino-acid l-tyrosine was selected as the unknown test structure to be used, in the form of the isomorphous hydrochloride and hydrobromide. The well-formed crystals obtained were assigned to the non-centrosymmetric monoclinic $P2_1$ space group. Zero-layer Geiger counter observations with monochromatized copper radiation were collected from cylindrically ground specimens with either the a or b crystal axis parallel to the cylinder axis. The unexpected finding was made that $I_{0kl} \neq I_{0\bar{k}\bar{l}}$; the observed difference averaged about 8 per cent but reached 50 per cent in an extreme case. Some typical comparisons are made in Table 1.

Table 1

	Tyrosine hydrochloride ($\Delta f'' = 0{\cdot}83$)			Tyrosine hydrobromide ($\Delta f'' = 1{\cdot}1$)		
hkl	F^2_{0kl}	$F^2_{0\bar{k}\bar{l}}$	$\Delta(F^2)_{calc.}$	F^2_{0kl}	$F^2_{0\bar{k}\bar{l}}$	$\Delta(F^2)_{calc.}$
020	570	641	66	725	895	110
002	73	73	0	439	459	0
011	220	207	21	98	59	31
041	354	298	47	1,320	1,240	50
052	93	113	23	665	691	31
035	178	147	30	195	189	40
016	221	231	17	320	341	23
055	2·5	5·8	0	22·2	22·9	0
027	288	269	26	960	876	22
0.2.11	100	103	0	610	610	0

It is noteworthy that $I_{00l} = I_{00\bar{l}}$ for the [100] zone measurements and $I_{h0l} = I_{\bar{h}0\bar{l}}$ for the entire [010] zone.

Tests were then made on a number of other crystals, which quickly established that the above condition was observed only when a heavy atom and a polar axis were involved. Tests were made with molybdenum and with chromium radiation, and non-equivalences of the same order of magnitude were found. A final decisive experiment was carried out with rubidium hydrogen tartrate[2], a compound for which similar intensity differences with exciting radiation have been found and have been explained as due to anomalous scattering. This compound gave non-equivalent intensities with chromium radiation which were parallel in every respect, but smaller in magnitude than those observed with exciting radiation.

The magnitude of the effect is great enough to allow it to be seen clearly on photographs in the case of some reflexions. The surprisingly large effect observed for tyrosine hydrobromide with copper radiation must clearly be due to excitation of the L-electrons even though the absorption edge is at $\lambda \cong 8$ A., since the K absorption edge at $\lambda \cong 0{\cdot}92$ A. cannot contribute. Assuming all eight L-electrons contribute, a prediction of the magnitude of the effect on the basis of Hönl's[3] calculations leads to satisfactory agreement with experiment. Table 1 gives such a comparison; a value of $\Delta f''$, the imaginary component of the bromine scattering amplitude, of 1·1 was used. In the case of chlorine, the K absorption edge is at $\lambda \cong 4{\cdot}4$ A., and with copper radiation the principal effect would be expected from the K-electrons. Using a value of $\Delta f'' = 0{\cdot}83$ taken from James[4], satisfactory agreement with experiment is again obtained, as can be seen from Table 1. Thus it is clear that the initial feeling of surprise that one feels at such a wholesale failure of Friedel's law is not justified.

The significance of the above findings for direct structure determination by Fourier synthesis in the non-centrosymmetrical case is at once apparent. In the case of tyrosine hydrochloride and hydrobromide, a direct solution of the structure has been readily obtained using no structure hypotheses, but only the information contained in the measurements themselves. The results of this investigation will appear in due time.

The success of the method is clearly dependent on accurate intensity measurements, preferably those made with a Geiger counter; however, the most commonly available radiations can successfully be used.

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Nuclear Spin and Hyperfine Structure of Radioactive Silver, $^{111}_{47}$Ag

An atomic beam magnetic resonance apparatus[1] has been constructed, and the nuclear spin and hyperfine structure separation of the $^2S_{1/2}$ ground state of silver-111, of half-life 7·5 days, have been measured. Also a new value of g_J for silver has been derived from the experimental results.

The nuclear spin is $\frac{1}{2}$ in units of $h/2\pi$, which confirms the value of McGinnis[2] and of Lemonick and Pipkin[3]. The transition ($F = 1 \longleftrightarrow 0$, $m_F = 0 \longleftrightarrow 0$), which is independent of the field to the first order, was observed at a magnetic field of 2·3 gauss, giving a value for the hyperfine structure separation of $|\Delta\nu| = 2{,}204{\cdot}54 \pm 0{\cdot}05$ Mc./sec. This agrees with the tentative value $2{,}180 \pm 100$ Mc./sec. given by Lemonick and Pipkin[3].

The transition ($F = 1$, $m_F = 1 \longleftrightarrow 0$) was observed at several fields up to 263 gauss, from which was calculated

$$g_J(\mathrm{Ag}, {}^2S_{1/2}) = 2{\cdot}00242 \pm 0{\cdot}00011,$$

assuming μ_I (^{111}Ag) < 0. The choice of a positive sign for the nuclear magnetic moment of silver-111

leads to a value of g_J (2·00258) outside the limits of error of the value $g_J(\mathrm{Ag}, {}^2S_{1/2}) = 2{\cdot}00224 \pm 0{\cdot}00020$ given by Wessel and Lew[4]. On this evidence we conclude that the nuclear magnetic moment is negative.

With the values of the hyperfine structure of silver-107 and silver-109 given by Wessel and Lew[4], the ratios

$$\frac{\Delta\nu(^{111}\mathrm{Ag})}{\Delta\nu(^{107}\mathrm{Ag})} = + 1{\cdot}287278 \pm 0{\cdot}000059$$

$$\frac{\Delta\nu(^{111}\mathrm{Ag})}{\Delta\nu(^{109}\mathrm{Ag})} = + 1{\cdot}115127 \pm 0{\cdot}000048$$

are found. These are sufficiently accurate for a determination of the hyperfine structure anomaly (expected to be about 0·5 per cent), when the nuclear magnetic moment of silver-111 can be measured precisely at some future time. At present we can only give a value μ_I (^{111}Ag) = − 0·145 n.m. accurate to about 1 per cent.

The details of the experiment are to be published elsewhere.

We are indebted to the Royal Society for a grant from the Paul Instrument Fund towards the cost of the apparatus.

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Structure of Polyglycine

Nearly twenty years ago, Meyer and Go[1] described the X-ray diffraction powder photograph of some glycine peptides, and found that different photographs were obtained from polyglycine according to the method of preparation. When the polymer was made by decomposition of the N-carboxy glycine anhydride in the presence of pyridine, reflexions corresponding to 4·4 A. and 3·45 A. were observed; but the same polymer precipitated by water from aqueous lithium bromide solution gave a photograph in which a reflexion at 4·15 A. was predominant. Subsequent observations[2–4] have related to the first form, which may be produced by casting from solution in dichloracetic acid or in trifluoracetic acid. It will be convenient to refer to this form as polyglycine I, and to the form characterized by the 4·15-A. reflexion as polyglycine II.

It has recently been found[4] that the two forms have different infra-red spectra. Whereas polyglycine I is a typical β-polypeptide, with absorption bands at 1,630 cm.$^{-1}$ (C=O) and 1,530 cm.$^{-1}$, polyglycine II has bands at 1,648 cm.$^{-1}$ (C=O) and 1,558 cm.$^{-1}$. The C=O mode of the second form, therefore, does not fall within the range found for either α- or β-synthetic polypeptides[5]. Other bands enable polyglycine I and II to be distinguished; the most convenient are at, respectively, 1,015 cm.$^{-1}$ and 1,026 cm.$^{-1}$. Under suitable conditions of precipitation, which were found by examining the infra-red spectra, polyglycine II can be obtained in a pure form. The X-ray diffraction diagram of this pure form is shown in Fig. 1. It would appear that Meyer and Go's polyglycine (shown in Plate II of their paper) was a mixture of I and II.

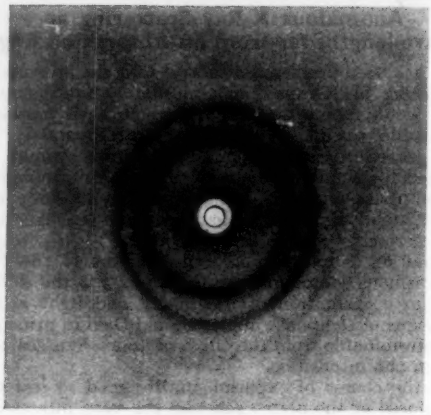

Fig. 1

The diffraction pattern of polyglycine I contains a reflexion at a spacing of 1·16 A. A reflexion occurring at this spacing in other β-polypeptides and silks is the 006 reflexion (*c* is the molecular chain axis), and if polyglycine consists of extended polypeptide chains, strong reflexion would be expected very near this spacing whether the chains were packed in a rectangular or a triclinic cell[4]. We have found no reflexion corresponding to a spacing in the neighbourhood of 1·16 A. in polyglycine II, showing that the two forms do not arise from different ways of packing extended (or nearly extended) chains; the chains in the two forms must have different configurations. This also follows from consideration of the relative intensities of the rings in the two powder photographs. The relative intensities of the equatorial reflexions from a given crystalline arrangement of extended (β) chains may be estimated from optical transforms of the *c*-axis projection. It is readily seen that the 3·45-A. reflexion should be somewhat stronger than the 4·4-A. reflexion if, following Astbury[3], these are indexed as 010 and 100 respectively; and in fact this is observed in polyglycine I, the β-form. However, to interpret polyglycine II in terms of a nearly extended chain would require us to take the very intense 4·15-A. reflexion as 100, with the next strongest (3·1 A.) as 010, in order to get a reasonable molecular packing. The predicted intensities for such an arrangement are quite different from those observed.

The very intense 4·15-A. reflexion appears to come from planes which are parallel or nearly parallel to the fibre axis (see below). The high intensity shows that the electron density has a very marked periodicity of 4·15 A., and it is reasonable to conclude that this is the separation of layers of polypeptide chains, possibly in hexagonal array. The α-helix (which would give hexagonal packing) can be excluded, since with such close approach of chains the density would be impossibly high (more than 3 gm./c.c.).

Of the various structures which have been proposed for polypeptide chains, only two appear to provide reasonable values for the density, and optical transforms of these, the 2·2$_7$ helix[7] and the unrotated parallel polar sheet[8], have been examined. Space-filling models of the polar sheet show that interplanar distances of about 4·15 A. and 3·6 A. occur; but the optical transform shows that these reflexions

should appear with comparable intensities, whereas the X-ray photograph shows a very weak ring corresponding to 3·8 A. and an overwhelmingly strong 4·15-A. reflexion (see Fig. 1). It seems, therefore, unlikely that a polar sheet structure is present.

Transforms of the $2\cdot2_7$ helix based on a 10$\bar{1}$0 reflexion of 4·15 A. lead to a prediction of intensities in general agreement with those observed in the X-ray powder photograph; but the details are not in agreement. In particular, no reflexion corresponding to the residue repeat 2·75 A. is seen. In a triclinic cell, such a reflexion would not be expected, since there is no reciprocal lattice point corresponding to 2·75 A.; but clearly such a possibility cannot be examined profitably until a fibre photograph is obtained. The density predicted for such an arrangement of $2\cdot2_7$ helices is 1·67 gm./c.c., which is considerably higher than the measured density of polyglycine II (1·43 gm./c.c.).

The methods by which polyglycine II may be prepared suggest that it might be an intra-chain hydrogen-bonded structure. Casting from any solvent such as dichloracetic acid invariably produces a predominance of the β-form, and we have found that precipitation from solution is generally necessary in order to prepare form II. The only method we have found which produces coherent films of form II is to prepare films in the presence of a salt. The polymer is dissolved in a mixture of formic acid, and calcium chloride and the formic acid dried off. The calcium chloride may then be washed out with alcohol, leaving a spongy film. It appears likely that the effect of the salt is to reduce the probability of intermolecular hydrogen bonding. If films made in this way are rolled, a small amount of orientation of form II is obtained which indicates that the 4·15-A. reflexion is probably equatorial rather than meridional. In addition, if the films, which from infra-red and X-ray examination are found to contain no β-material, are rolled hot, a small amount of doubly oriented β-material is produced. The β-material is quite well oriented, the mean direction of the chain axis lying in the direction of rolling; a similar orientation is observed in the $\alpha \rightarrow \beta$ transformation in other synthetic polypeptides.

These facts suggest very strongly that the molecules of form II are folded and that on rolling a number are pulled out into the β-form. It would appear that here we have strong evidence for a configuration of the polypeptide chain which is outside the range of structures hitherto accepted.

No evidence of the α-helical form of polyglycine has been found, except observation of parallel dichroism of the NH-band in a specimen which had been stretched in polystyrene[6]. Recent observations suggest that this may really be a 'cross β' structure, since the C=O band accompanying the dichroic NH band has the β- rather than the α-frequency.

The fact that the 1,015 cm.$^{-1}$ band of polyglycine disappears when the β-form is converted into form II shows that the absence of this band in the spectrum of polymers containing glycine is no proof that the structure is one in which there are no glycyl–glycyl bonds. Especially in the case of alanine–glycine copolymers, and in silks, the possibility that frequency changes are caused by change of molecular configuration must be considered. Since criteria for the recognition of α- and β-forms have now been known for some years[6], we consider that these possibilities should be considered before conclusions on the chemical constitution of silk are based on the appearance or absence of bands in the spectrum[9].

The work we have here reported shows that there exists, in polyglycine at least, a configuration of the polypeptide chain other than the α-helix and the normal β-forms.

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Positive-Point D.C. Corona

With a point-to-plane gap geometry, a visible (corona) discharge can occur at much lower values of applied gap voltage than those necessary to cause spark breakdown. Such a positive-point d.c. corona discharge in room air has been studied by recording the light emitted with an 11-stage photomultiplier. The output from the photomultiplier was delayed, amplified by 'distributed' amplifiers[1], and displayed on a high-speed cathode ray oscilloscope. The time base of the oscilloscope was triggered by the output of light through a separate photomultiplier, distributed amplifier and thyratron trigger circuit.

The discharge in room air could occur in two distinct forms: (1) a filamentary form which showed discontinuities of current and light throughout a wide range of applied voltage (that is, 'burst pulses', 'pre-onset streamers' and 'pre-breakdown streamers'); (2) a diffuse glow discharge, in which the mean gap current, measured by a galvanometer, was less (~ 40 per cent) than in the filamentary discharge for the same gap geometry at a given value of applied voltage. The spark breakdown voltage was higher and the mean gap current immediately preceding breakdown was lower for the glow discharge than for the filamentary discharge for the gap geometries investigated. The glow discharge showed discontinuities of current and light only over a narrow range of applied voltage (~ 200 V.) near onset; these discontinuities were presumably associated with a 'Geiger' counting action in the gap.

The filamentary form of discharge was investigated. The discontinuities of current and light were observed to be pulses of short duration. The current pulses were similar to those observed by other workers[2,3]. A light pulse was associated with each current pulse. The light pulses occurred about 5×10^{-8} sec. after the current pulses, as shown by their relative displacements from the initiation of the oscilloscope time-base. The instrumental part of this delay was

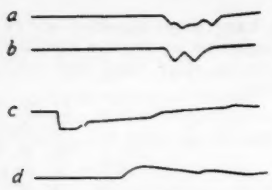

Fig. 1. Tracings of typical pulses observed with an applied gap voltage of 16 kV.
(*a*, *b*) High-amplitude initial portion of light pulse, sweep duration 0·56 μsec.; (*c*) low-amplitude portion of light pulse, sweep duration 2·3 μsec.; (*d*) electrical pulse, sweep duration 0·56 μsec.

about $2{\cdot}5 \times 10^{-8}$ sec. The light pulses (Fig. 1) showed an initial portion of high light intensity and short duration (~ 6–2×10^{-8} sec.), followed by a portion of lower intensity (~ 1 per cent) and relatively long duration ($\sim 10^{-6}$ sec.). The initial portions of the light pulses usually showed several irregular peaks and were identifiable with the pulses recorded by English[4] and Amin[2]. The peaks were thought to be associated with branching of the discharge, such branching apparently taking place when the discharge was operated into a weak field region. If branching of the discharge was the explanation for the peaks, then the branches did not appear to be propagated simultaneously but in rapid succession. The low-intensity portion of the light pulses corresponded to the light pulses observed by Gaunt and Craggs[5].

The spatial distribution of the emitted light was investigated by projecting an enlarged real image

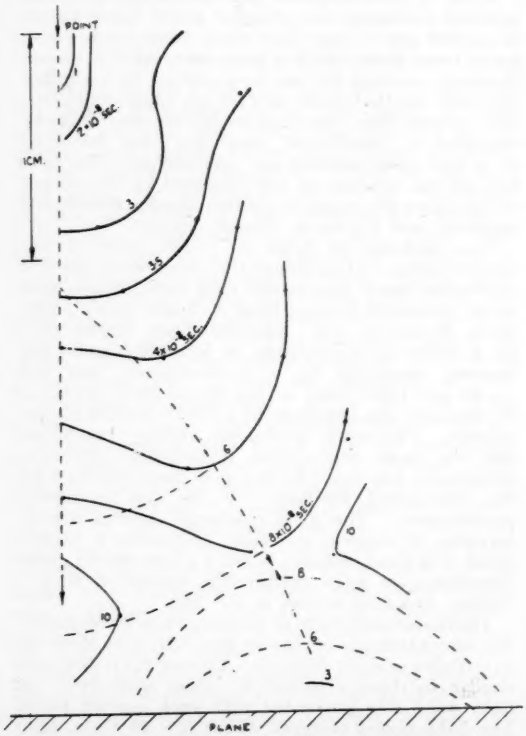

Fig. 2. Observed spatial growth of 'breakdown streamer'. Point radius 0·228 mm.; applied voltage 16 kV.

of the axis of the gap in the plane of the photocathode of the recording photomultiplier. Light pulses were observed from all regions of the gap. By measuring the relative displacement of the pulses along the time-axis of the oscillograms, the spatial growth of the discharge could be determined. The results shown in Fig. 2 were obtained with an applied voltage of 16 kV., a tungsten point of radius of curvature 0·228 mm., a gap-length of 3 cm., an aluminium plane cathode of 15 cm. diameter and a resistance of 200,000 ohms in series with the point electrodes. The effective sampling area was 3 mm. in diameter.

The discharge was propagated from the point steadily and with constant luminosity for a distance of about 1 cm., after which the luminosity decreased and branching of the discharge was thought to occur. About three, but up to five, branches were possibly associated with each discharge sequence, and about one in three branches was estimated to continue to be propagated along the axis. When branches were deflected from the axis, possibly by space charge in the gap, then a visible discharge was observed to grow from the plane cathode. Presumably the visible discharge from the cathode was caused by photo-electrons from the cathode causing excitation, even though moving in a very low field ($x/p \sim 1{\cdot}4$ volts/cm. per mm. mercury pressure).

The form and growth of the individual events in the filamentary discharge were very similar to the type of growth which contributed to the founding of the streamer theory, where the principal secondary mechanism in the discharge was considered to be photo-ionization in the gas. Most of the observations could be explained satisfactorily by the streamer theory[6]. It is hoped to publish elsewhere a full account of the results and their implications.

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Ion-Exchange Chromatography in Alcohol

In the technique of ion-exchange chromatography, the order in which compounds are eluted from a column depends basically upon differences in their ionization constants; but other factors modify and in many instances reverse the expected order[1]. This is illustrated in Fig. 1, where the elution peaks of a number of acids from a 'Dowex' resin are plotted against their pK values. Although there is a definite correlation between acid strength and ease of elution, the points are very scattered, and in particular acids containing an aromatic group are eluted much later than would be expected on the basis of their ionization constants.

The suggestion has been made by Martin[2] that separations on all chromatograms consisting of a

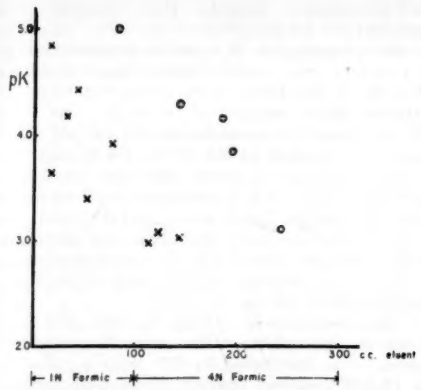

Fig. 1. Ion-exchange chromatography on 'Dowex 1–×8'. The resin was converted to the formate form as described by Busch, Hurlbert and Potter (ref. 10), and the chromatograms were run in a column 12 cm. × 1 cm., eluting with 1 *N* and 4 *N* aqueous solutions of formic acid. The *pK* values of the acids were taken from the literature. Elution peaks of acids containing a benzene ring are indicated by ⊙

stationary gel phase and a moving liquid phase will be influenced by the relative solubility of the solutes in the two phases. Applied to ion exchange chromatography, this means that the rate of travel of compounds on a column should be affected by their partition coefficients, based on solubility, between the eluting solvent and the swollen ion-exchange resin. In our experiments, the eluting solvent is primarily an aqueous solution, while the gel phase, although it contains water and electrolyte, has in addition some of the characteristics of an organic solvent imparted to it by the polystyrene backbone, which makes up about half the weight of the hydrated gel[3]. Therefore, acids which are relatively water-soluble should favour the moving phase and their rate of travel should be accelerated relative to water-insoluble acids. This concept helps to explain the observed retardation of acids containing an aromatic group, which as a class have limited solubility in water.

Further evidence that partition coefficients take a role in ion-exchange chromatography has been obtained by replacing the water in the eluting solvent with absolute ethanol and repeating the chromatograms with the acids used in Fig. 1. Since alcohol is also an ionizing solvent, the resulting chromatographic pattern is still apparently based on an ion-exchange process, while the shifts in elution peaks of the various acids from their previous positions can be predicted from solubility considerations (Fig. 2). Acids with a greater solubility in alcohol than in water, such as those containing a benzene ring, were eluted much earlier in the alcoholic medium, whereas the more water-soluble acids were retarded to varying degrees. Similar results have been obtained by Stein and Moore[4], who found that adding 1 per cent of benzyl alcohol to the eluent tended to increase the rate of travel of the aromatic amino-acids relative to others, while inclusion of 25 per cent propyl alcohol preferentially accelerated those possessing longer non-polar side-chains.

The position of individual acids in our chromatograms was determined by running them in small groups and identifying them by melting points and by paper chromatography in a *sec*-butanol/water/formic acid (80 : 8 : 12) system similar to one used by Kowkabany and Cassidy[5]. This system gives R_F values almost identical with those obtained with the *n*-butanol/water/formic acid system of Lugg and Overall[6], but has the advantage that *sec*-butanol esterifies less readily with the formic acid.

The R_F values of compounds in such an alcohol – water system are related to their partition coefficients between the alcohol and water by the equation[7]

$$\alpha = \frac{\text{concentration in water phase}}{\text{concentration in alcohol phase}} = \frac{A_L}{A_S}\left(\frac{1}{R_F} - 1\right)$$

where A_L/A_S, the ratio of the volumes of alcohol and water phases in the chromatogram, is a constant for any given system. From this it can be seen that compounds with partition coefficients favouring the aqueous phase will have low R_F values whereas those with coefficients favouring the alcohol phase will have high R_F values.

It is therefore not surprising to find that acids with high R_F values ($>0{\cdot}80$) are all eluted more readily on the ion-exchange chromatograms when alcohol is substituted for water, while acids with lower R_F values ($\leqslant 0{\cdot}80$) are all retarded by the use

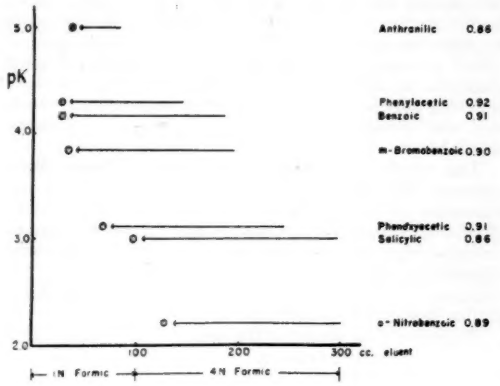

Fig. 2(*a*)

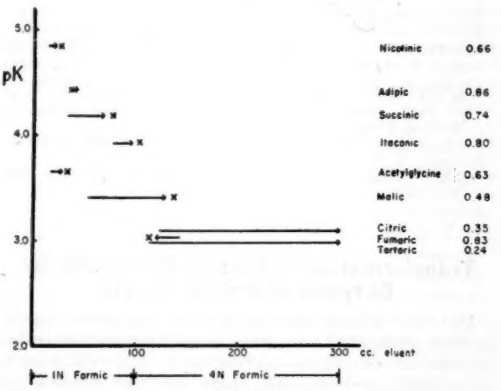

Fig. 2(*b*)

Fig. 2. Ion-exchange chromatography in ethanol. (*a*) Acids containing a benzene ring. (*b*) Acids lacking a benzene ring. The arrows indicate the direction and magnitude of the shift of the elution peaks from their positions in Fig. 1. Arrows extending to or from the line marking 300 c.c. of eluent indicate an elution peak beyond this point. The numbers listed after the names of the individual acids are their R_F values in the paper chromatographic system of *sec*-butanol/formic acid/water

of alcohol. This may perhaps be used as a rough method for predicting whether substances which are eluted together in an aqueous ion-exchange chromatogram could be separated by using alcohol. It should be recognized, however, that this relationship may not apply in all cases, especially since *sec*-butanol rather than ethanol was used in the paper chromatograms.

The demonstration that absolute ethanol can be used as a medium for ion-exchange chromatography promises to extend the usefulness of this technique to include many acids and bases with limited solubilities in water. The separation of long-chain fatty acids is at present being investigated in our laboratory, while Kornberg and Pricer have used chromatography in alcohol on a 'Dowex' resin for purifying a diacyl-phosphatidic acid[8], and Kennedy has used a similar method for separating phosphatides of mitochondria[9]. It appears that high recoveries can be obtained from alcohol columns, and in the experiments reported here all except one of the acids were recovered in better than 80 per cent yield although no special attempt was made to obtain quantitative recoveries (that is, the eluting solvent was removed by drying in an oven at 80° C. and some losses undoubtedly occurred due to volatility of the acids at this temperature). The use of ethanol, and of other ionizing solvents such as methanol, higher alcohols, ketones, etc., may also, by virtue of their differing solvent properties, permit separations which are not possible by other techniques at present available.

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Transformation of Pentose Phosphates by Enzymes of Animal Origin

In the hexosemonophosphate oxidative cycle, pentose phosphate isomerase is required for the interconversion of ribose-5-phosphate and ribulose-5-phosphate[1], a necessary stage for the subsequent enzymic re-synthesis of hexose from pentose[2]. The enzyme has been much purified from alfalfa leaves[3], but little is known of the animal system, although the facts that xylulose-1-phosphate may be a precursor of ribose in crude liver extracts[4], and that in spleen extracts[5,6] ketopentoses other than ribulose (xylulose and 3-ketopentose) may be formed from ribose-5-phosphate, suggest that pentose transformations may be complex.

For the preparation of suitable systems, acetone-dried powders from rabbit muscle and washed red blood cells of the horse were extracted twice with ten times their weight of 0·05 *M* 'tris' buffer (tris(hydroxymethyl)-aminomethane) of *p*H 7. The extracts were heated at 55–60° C. for 5 min., freed from the resulting coagulum, and the fraction precipitated between 0·3–0·5 saturation with ammonium sulphate was suspended in water and dialysed. After rejection of the insoluble globulins, the freeze-dried material contains most of the pentosephosphate isomerase of the original extract, and remains active for months when stored at − 20°.

For the preparation of the barium salt of the ketopentose phosphate, the muscle preparation (30 mgm.) was incubated at 37° with a solution of 1 gm. (2,500 μ-moles) barium ribose-5-phosphate in 25 ml. water at *p*H 7. The ketopentose formed was measured by the Dische reaction (method of Axelrod and Jang[7]) until no further increase occurred (90 min.) and it remained unchanged at 930 μ-moles (37 per cent) for a further 30 min. After deproteinizing with perchloric acid, careful neutralization, and removal of aldoses with bromine and barium carbonate, the phosphate esters were adsorbed on a 'Dowex-1 (formate)' column and eluted with 0·1 *M* formic acid in 0·1 *M* sodium formate. By careful neutralization with barium hydroxide and precipitation with 4 vol. of ethanol, the vacuum-dried barium salt (357 mgm.) was obtained with a purity of 93 per cent based on ketopentose and 85 per cent based on ester-phosphorus content (800 μ moles ketopentose phosphate, or 32 per cent of the total initial pentose). At least 90 per cent of the total ketopentose was alkali-labile, and the rate of hydrolysis in *N* acid at 100° ($k = 5{\cdot}2 \times 10^{-3}$) also indicated a 5-position for the phosphate. The ratio of intensities in the orcinol reaction at 540/670 mμ we found to be 0·90–1·00 for chromatographically purified synthetic ribulose and 0·45–0·50 for xylulose. The free ketopentoses liberated by purified acid phosphatase from the above barium salt gave an intermediate value (0·55–0·60). The dephosphorylated de-ionized sugars separated sharply with 88 per cent recovery on a 'Dowex-1 (borate)' column[7] into two peaks, of which the first (51 per cent of total ketopentose in eluate) corresponded exactly in colour reactions and position on elution with pure xylulose and the second (49 per cent) with pure ribulose. No interconversion of the pure sugars similarly processed was detectable.

The enzyme prepared from red cells gave a similar proportion (43 per cent) of total ketopentose to pentose at 'equilibrium'. But the barium salt, prepared and treated as above, had orcinol ratio 0·78, and separation on the column showed that it was substantially the ribulose ester (peak I = 10 per cent, peak II = 90 per cent of total ketopentose; orcinol ratios 0·50 and 0·90 respectively). This barium salt, when incubated with the muscle preparation, lost 59 per cent of its total ketopentose (by conversion to ribose phosphate), while the remaining ketopentose was largely the xylulose ester (peak I, 71 per cent; peak II, 29 per cent of total bromine-resistant pentoses; orcinol ratios 0·50 and 0·98 respectively).

At least one enzyme in addition to the pentose phosphate isomerase is therefore active in the muscle preparation, and converts ribulose-5-phosphate to the xylulose ester. Since no 3-ketopentose[6] formation was detected, the enzyme is presumably a type of

'waldenase', causing inversion at $C_{(3)}$ of the pentose, and resembling that recently suggested as active in *Pseudomonas hydrophila*[6].

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Modification of Response to Adrenocorticotrophic Hormone by the Simultaneous Administration of Gonadotrophic Hormones

MANY facts suggest that the adrenal–gonad relationship is an intimate one[1]. Our previous work[2] has indicated that the mouse ovary, provided it is in the luteal phase, has an effect similar to that of the adrenal cortex. While appreciating that major species differences may occur, this finding led us to commence experiments on the adrenal–gonad relationship in the guinea pig, since the urinary steroids in this species are excreted in sufficiently large amounts to be determined by routine chemical methods. It has now been shown that the response to adrenocorticotrophic hormone (ACTH) is modified by the simultaneous administration of gonadotrophins.

Ten similar experiments, each using four mature female guinea pigs, were planned as follows:

Day of experiment	'ACTH-only' group. Guinea pigs *A* and *B*	'ACTH + Gonadotrophin' group. Guinea pigs *C* and *D*
1	No treatment	No treatment
2, 3	ACTH	ACTH
4 to 15	No treatment	C.G. + P.M.S.
16, 17	ACTH	ACTH + C.G. + P.M.S.

Subcutaneous injections of 10 I.U. ACTH gel (Armour Laboratories or Wilson Laboratories) twice daily, 50 I.U. pregnant mares' serum gonadotrophin (P.M.S.; Boots Pure Drug Co., Ltd.) in distilled water once daily, and 50 I.U. chorionic gonadotrophin (C.G.; Organon Laboratories, Ltd.) in distilled water once daily, were given into separate sites. Animals were maintained on a standard diet supplemented by 15 gm. cabbage daily. Gonadotrophin treatment led to extensive ovarian luteinization. 17-Ketosteroids and 17-ketogenic steroids were determined on 24-hr. collections of urine from pairs of animals by the method of Norymberski and others[3]. Urine was collected into flasks containing a few drops of chloroform, and standing in vacuum flasks containing solid carbon dioxide. Burstein, Dorfman and Nadel[4] have shown that the main corticosteroids in normal guinea pig urine are cortisol and 6β-hydroxycortisol.

Results, expressed as the mean excretion of steroid in mgm. ± S.D./guinea pig/24 hr., are summarized as follows:

Days of experiment	2, 3	16, 17
'ACTH-only' group		
17-ketosteroids	1·00 ± 0·43	0·99 ± 0·33
17-ketogenic steroids	0·60 ± 0·27	0·59 ± 0·28
'ACTH + gonadotrophin' group		
17-ketosteroids	1·00 ± 0·37	0·99 ± 0·37
17-ketogenic steroids	0·62 ± 0·22	0·36 ± 0·16

The mean difference in 17-ketosteroid excretion between the first and second periods of ACTH administration was $-0{\cdot}01 \pm 0{\cdot}22$ mgm. for the 'ACTH-only' group, and $-0{\cdot}01 \pm 0{\cdot}29$ mgm. for the 'ACTH + gonadotrophin' group. These results are not significantly different ($P = 0{\cdot}75$). The mean difference in 17-ketogenic steroid excretion between the first and second periods of administration of adrenocorticotrophic hormone was $-0{\cdot}01 \pm 0{\cdot}10$ mgm. for the 'ACTH-only' group and $-0{\cdot}26 \pm 0{\cdot}15$ mgm. for the 'ACTH + gonadotrophin' group. These results are significantly different ($P = 0{\cdot}007$).

The urinary excretion of 17-ketogenic steroids in response to administered adrenocorticotrophic hormone has therefore been modified by treating the animals with gonadotrophic hormones, and experiments are in progress to try to elucidate this effect. Gonadotrophin treatment did not alter the urinary 17-ketosteroid response to adrenocorticotrophic hormone.

We are indebted to the Medical Research Council for a gift of adrenocorticotrophic hormone.

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Separation of Ehrlich Ascites Tumour Cells from Other Cellular Elements

THE experimental production of ascites tumours has offered an ideal material for biological, physiological and biochemical research on neoplastic cells[1]. For many problems, however, the variable admixture of leucocytes and other contaminating host cells in the ascites tumours (cf. ref. 1) implies a source of error which in certain cases may be of great importance. We have therefore investigated the possibility of reducing the concentration of such cells with the aid of a counter-streaming centrifuge, the principle of which has already been described by one of us (P. E. L.)[2]. In this centrifuge, constructed mainly for the separation of differently sized particles of the same specific density, liquid containing the particles to be separated is forced to stream through a conical centrifuge tube against the centrifugal force. Here the bigger particles down to a required size are concentrated (fraction *M*), whereas the smaller ones are carried off by the continuous stream of liquid to a second tube of a different shape where they are made to sediment (fraction *G*).

The tetraploid line of the Ehrlich ascites tumour[1] was used for the experiments. Cell samples were withdrawn from the peritoneal cavity at various intervals after inoculation. They were diluted with Krebs's phosphate Ringer solution, containing 1 per

cent glucose and 1 per cent gelatine. The same solution was used as the flowing suspension medium in the centrifuge. The separation was carried on for 60 min. at 300 r.p.m. and a streaming velocity of about 0·25 ml. sec.$^{-1}$. The greatest diameter of the conical tube was 2·40 cm., and the distance between this and the theoretical point of the cone 18·0 cm., the latter being 24·0 cm. from the centre of rotation. In most experiments the cells are quite undamaged after the separation. Tumour cells and non-tumorous exudate cells were counted differentially on Papanicolaou smears as described elsewhere[3]. Some experimental figures are collected in Table 1.

Table 1. Percentage of Non-tumorous Exudate Cells in Various Samples before and after Centrifugation

Exp. No.	Original suspension	Fraction	
		M	*G*
1	13·0	3·8	3·6
2	17·3	9·0	2·8
3	40·7	12·6	15·8
4	20·5	11·2	5·2

In three of the four experiments, the percentage of small cells has been reduced to about one-fourth of the original value (in one experiment to one-sixth). All cells having the same specific density, one would expect to find most of the small cells in fraction *G*; it is seen from Table 1, however, that the percentage of contaminating cells is often smaller in fraction *G* than in fraction *M*. The contaminating cells thus appear to have a higher specific density than the tumour cells.

A detailed description of the centrifuge will appear shortly in I.V.A.'s *Tidskrift för Tekniskt-vetenskaplig Forskning* (Stockholm). We are indebted to Ely Lilly and Co. for financial support.

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May 30.

[1] Klein, G., *Exp. Cell Research*, 2, 518 (1951).
[2] Lindahl, P. E., *Nature*, 161, 648 (1948).
[3] Klein, G., and Révész, L., *J. Nat. Cancer Inst.*, 14, 229 (1953).

Comparison of Rectal and Deep Body Temperature in the Calf

In the bovine animal as with other domestic mammals including man, the rectal temperature is generally accepted as a measure of deep body temperature, and it is widely used both in field and laboratory studies for indicating the state of thermal balance of cattle when subjected to climatic stress. Despite the possibility of thermal gradients within the rectum, as has been found in man[1], there is no obvious reason for doubting the validity of this assumption, at least as an approximation, when body temperatures are steady. However, under conditions of thermal stress, when body temperatures are rising, a constant and close relationship between rectal and deep-body temperature cannot be assumed, as there is almost certainly a delay before the temperature of the fæcal mass reaches equilibrium with that of the rectal wall. Consequently, an investigation has been made to study the validity of using rectal temperature as a measure of deep body temperature in Ayrshire bull calves, four to six months old. Cattle of this age and breed have already been used in studies of environmental physiology in a climatic chamber in this Institute[2].

A reasonable measure of average deep body temperature would seem to be that of the pooled and well-mixed venous return to the heart. Eichna and others[3] and Mather, Nahas and Hemingway[4] failed to find any temperature difference across the lungs in man and dog, and assuming this to be true also of the bovine, the temperature of the blood leaving the left side of the heart should be a valid measure of both deep body temperature and of the blood supplying the temperature-regulating centre in the brain. For this reason, and because the temperature of the well-mixed venous blood in the pulmonary artery is difficult to measure without extensive surgery, the temperature of the free-flowing arterial blood in the bicarotid trunk was compared with rectal temperature.

A fine copper-constantan thermocouple, threaded into a narrow polyvinyl chloride plastic tube, sealed at the couple end, was introduced into the right carotid artery by means of aseptic surgery. The tube was passed down the inside of the artery until the thermocouple junction was estimated to lie in the bicarotid trunk. Five animals were used, and although on examination several days later an embolism was invariably found at the point of entry of the thermocouple wires into the artery, the junction was found to be lying in free-flowing blood passing up the left carotid artery. The leads were brought out through a stab wound in the skin lateral to the main incision, and terminated on a 'Perspex' button sewn on to the skin over the stab wound. A protective cap was then fitted over the button, and this allowed the animal free movement in the byre. Recovery was complete in three to four days, when the animal appeared to be normal. The calf was then placed in the climatic chamber for periods of up to 6 hr. at 20°, 30° and 40° C. at a constant low humidity (17 mgm./l. absolute humidity), and at 35° and 40° C. at a constant high humidity (7 mgm./l. saturation deficit). During the experiment, the protective cap was replaced with a cap containing copper and constantan contacts from which leads were attached to the temperature-measuring system which has already been described[2,5]. Rectal temperature was expressed as the average of almost simultaneous readings from four thermocouples each 2·5 cm. apart, the deepest being 15 cm. from the external anal sphincter. Only slight and random variations occurred between the temperatures measured by the rectal thermocouples at different depths of insertion. Measurements of rectal and carotid temperatures were taken every 5 min.

In all five animals, the carotid blood temperature was 0·1–0·3 deg. C. below that of the rectum at every low-humidity exposure. This difference remained fairly constant for any one animal at any one environmental temperature, whether body temperatures were relatively steady or were slowly climbing (Fig. 1). At the environmental conditions of 35° C. and high humidity, when body temperatures were rising, a difference between carotid and rectal temperatures remained, though in some instances the difference was less than that noted before the humidity was raised (Fig. 2*A*). At 40° C. and high humidity,

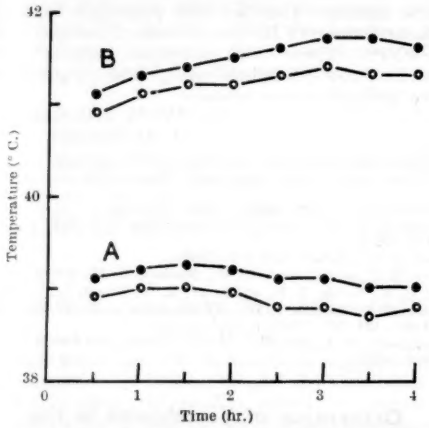

Fig. 1. Rectal (—●—) and carotid blood (—○—) temperatures of a calf while it was subjected to environmental temperatures of (*A*) 20° and (*B*) 40° C. Humidity was maintained at 17 mgm. water/l. in each experiment. Readings were taken at 5 min. intervals and plotted as half-hourly averages

when virtually all channels of heat loss were denied the animal and body temperature rose steeply at a rate determined by its heat production, the temperature difference disappeared and rectal and carotid temperatures became identical (Fig. 2*B*). Sometimes the carotid blood temperature was even slightly higher than that of the rectum.

The change in relationship between rectal and arterial blood temperatures when the humidity is raised at 40° C. is at least partly due to the delay in temperature changes of the fæcal mass. However, these are more extreme conditions of thermal stress than are normally encountered under field conditions, and it is concluded from these experiments that although rectal temperature is slightly above the temperature of the blood leaving the left side of the heart under any but the most adverse conditions of climatic stress, for all practical purposes pertaining to environmental studies with the bovine animal upward changes in rectal temperature in response to external heat stress indicate changes of a similar magnitude in 'deep body temperature'.

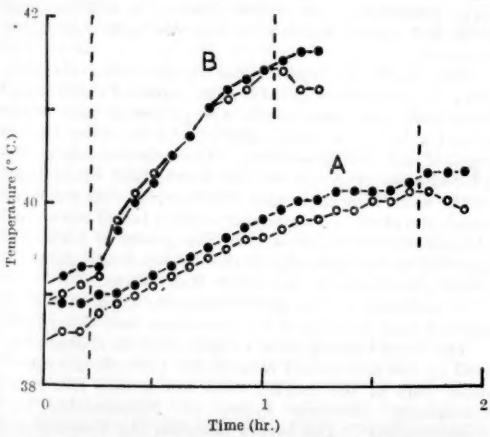

Fig. 2. Rectal (—●—) and carotid blood (—○—) temperatures of a calf while it was subjected to environmental temperatures of (*A*) 35° and (*B*) 40° C. In each experiment high humidity conditions (7 mgm./l. saturation deficit) were maintained in the room during the period within the vertical interrupted lines. The humidity was low at the beginning and end of each experiment

The 'Perspex' button and caps were designed and made by Mr. W. Nisbet of this Institute.

JOHN BLIGH

The Hannah Dairy Research Institute,
Kirkhill, Ayr.
April 5.

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Modification of the After-Potential of Single Muscle Fibres by 2:4-Dinitrophenol

INTRACELLULAR recording of electrical activity in the excised sartorius muscle of *Hyla coerulea* shows a negative after-potential of 20–25 mV. with a half-time of decay ($t_{1/2}$) of 8–12 m.sec. at 25° C. The time of recovery to resting potential level is increased to $t_{1/2}$ of 18–25 m.sec. when K^+ is absent from the glucose–phosphate–Ringer medium. Successive increases of K^+ concentration up to 15 N/1,000 cause successive shortenings of repolarization time to $t_{1/2}$ 6 m.sec.[1]. These processes are faster by one-third in *Rana catesbiana*. The after-potential of *Hyla* muscle is prolonged, also, by reduction of Na^+ in the medium to 20 M ($t_{1/2}$ 15–20 m.sec.) or by increase of H^+ to pH 6·5, which gives $t_{1/2}$ of 28 m.sec.

The possibility that the effect of ions upon repolarization is linked with energy supplies is suggested by Lorente[2], who used hypoxia for changing the positive after-potential of nerve. To test whether phosphate were the energy source of muscle after-potential ionic movements, 2:4-dinitrophenol (DNP) was added to the Ringer solution. In 20 min. 2 mM DNP abolished all the negative after-potential (Fig. 1,*b*). After another 10 min. it slightly reduced the resting potential to 60–65 mV. The endplate potential was not significantly altered, though the overshoot was reduced by 8–10 mV. (Fig. 1,*c*). Soaking in normal Ringer solution restored the after-potential to its previous voltage and duration. Addition of 2 mM DNP to a medium from which K^+ was omitted prevented the normal rise of resting potential to 105 mV.; but it abolished the after-potential. In an atmosphere of nitrogen the sartorius muscle fibres were found to lose the greater part of the after-potential, and recovery followed the readmission of oxygen. Similarly, cooling the muscle to 6° C. eliminated nearly all the after-potential. The duration of the spike increased.

These findings may be interpreted as the consequences of reduction in available phosphate by the decoupling of oxidative phosphorylation, probably in the mitochondria[3,4]. Lack of oxygen would reduce phosphorylation. Active ion transfer then would be reduced. The negative after-potential would thus be the result of sodium extrusion (or possibly chloride intrusion) aided by phosphate energy, derived from oxidative sources. The effects of K^+ may follow competition for transfer between K^+ and the more actively transported ion.

Heart muscle. The intracellular record of action potentials of frog cardiac muscle cells shows pro-

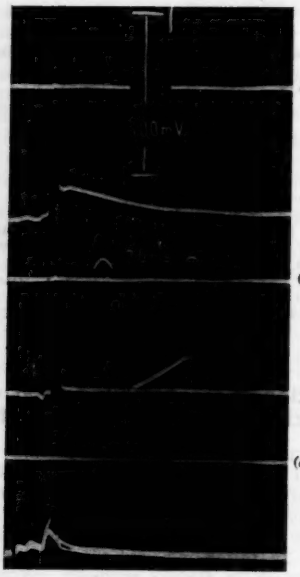

Fig. 1. (*a*) Intracellular muscle fibre action potential in normal glucose–phosphate–Ringer solution at 25° C. Resting potential, 85 mV.; overshoot, 46 mV.; (*b*) same muscle and conditions as (*a*) with addition of 2 m*M* 2 : 4-DNP, after 20 min. soaking. The after-potential is eliminated; (*c*) another muscle after 30 min. in 2 m*M* DNP, at the nerve-muscle endplate, showing summation of two endplate potentials. A second sweep with action potential is superimposed. Resting potential, 60 mV.; overshoot, 38 mV.

longed depolarization when the K^+ in the medium is reduced and some shortening of the depolarization time follows increase of K^+ concentration up to 15 *N*/1,000. Clinically in man, this effect of K^+ is detected as longer or shorter S—T intervals of the electrocardiogram in hypo- and hyperkalæmia respectively[5,6]. Reduced oxygen supply also shortens repolarization time. It seemed likely that the prolonged depolarization of the heart cell might, in part at least, be equivalent to the negative after-potential of skeletal muscle. Frog ventricular intracellular potentials were examined in the presence of 2 : 4 DNP at 25° C. The duration of the action potential was reduced from 660–700 m.sec. to 200 m.sec. without reduction in resting potential or overshoot. Longer time of action of DNP abolished the overshoot and left the ventricular action potential as a short event, occupying 90–110 m.sec. This is less than one-sixth the duration of the normal repolarization time at 25° C. and it took place without change of heart-rate. Neutral red 0·2 m*M*, when it has stained the muscle, also shortens the time-course of the action potential to one-third. It is a weak decoupling agent. Tae increased K^+ loss from DNP-treated heart muscle[7] is probably linked with decreased sodium extrusion during repolarization. The refractory period of cardiac muscle may thus be regarded as an energy-linked ion transfer which maintains the potential near zero until half a second has passed. Five-sixths of this time of depolarization can be abolished by DNP, probably by the decoupling of phosphorylation and exhaustion of phosphate stores.

The negative after-potential of skeletal muscle appears from this evidence to be an event homologous with the greater part of the long depolarization of cardiac muscle. The two slow potentials behave in a similar fashion to K^+ concentration changes and to 2 : 4-DNP. These slow potentials appear to be dependent upon phosphate energy and oxygen for the active process of ion transfer.

W. V. Macfarlane
J. D. Meares
Sir William MacGregor School of Physiology,
University of Queensland. March 31.

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Occurrence of Vertebrates in the Triassic of Israel

Vertebrate bones from the Triassic in southern Israel were noted by Shaw so early as 1947 [1]. Further, W. E. Swinton described a single nothosaurian vertebra from the same locality in 1952 [2]. During my first visit in 1953, it was possible to state that more or less well preserved vertebrate bones occur abundantly in the Triassic of Wadi Raman, and a more complete fossil was found and prepared at the Swedish Geological Survey at Stockholm. After preparation, this fossil could be identified as half of the dorsal armour of the turtle-like placodont *Psephosaurus*. Hitherto, only fragments of the dorsal armour of this reptile were known, found in the lowermost part of the Upper Triassic in Germany.

The new fossil shows not only the central parts of the dorsal armour but also the incisions for the neck and the fore and hind legs, the marginal part and parts of the ventral armour.

During 1954, the number of finds of vertebrate fossils increased and hundreds of fragments were collected. Among this material there are vertebræ, teeth and bones from the extremities of numerous nothosaurian and other reptiles, five imperfect skulls, of which one belongs to *Psephosaurus* and one to a large placodont, the middle part of a nothosaurian skull and others which have not yet been thoroughly studied.

The skull of *Psephosaurus* is the most complete one. The entire occipital region, parts of the vomeral area with two large teeth, the posterior part of the dorsal side of the skull, and one of the very typical jugales are well preserved. The relationship to the Placodontia is given by the teeth, and other parts of the skull also show this relationship. On the other hand, the skull of *Psephosaurus* from Israel has special characters, which show that the group of turtle-like placodonts was already distinctly separated from the other placodonts in the lower Meso-Trias.

In addition to the skull fragment, an almost complete dorsal armour of *Psephosaurus* was discovered.

The fossil-bearing layers begin with beds characterized by the ammonoid *Beneckeia*. I divide the uppermost part of the section with bones into five zones containing different types of *Paraceratites* and *Siniaceratites*[3]. The layers between the Ceratite and *Beneckeia* beds are of terrestrial origin, containing vertebrates and plant remains. The stratigraphical range of the new locality with its large vertebrate fauna begins in the deepest Lower Meso-Trias and

reaches the Upper Meso-Trias according to the classification by Spath[4]. The *Psephosaurus* from Wadi Raman is therefore the oldest known of the armoured branch of the Placodontia.

F. Brotzen

Swedish Geological Survey,
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[2] *Ann. Mag. Nat. Hist.* (12), 5.
[3] See G. al Din Hafez Awad, *Bull. Inst. d'Egypte* (1946).
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Age of Uraninites from Dimensions of their Unit Cells

Three years ago Dr. Wasserstein suggested in a communication in *Nature*[1] that "the generation by radioactive decay of smaller atoms of tetravalent lead within the crystal lattice of uraninites caused a shrinkage in the unit cell proportionate with time", and that this could be used for estimating their ages. In a more recent communication[2] he discussed this method in the light of a classification of uraninites into three types, namely, the equivalents of artificial UO_2, and materials having uranium – oxygen ratios of 1 : 2·33 (possibly U_3O_7) and 1 : 1·75 (possibly U_4O_7), respectively, and thinks that they are all characterized by a fluorite structure with different 'parameters' in the three cases.

Hoekstra and Katz[3] pointed out that the existence of these oxides in Nature is doubtful. In his answer Wasserstein mentions the occurrence of thorium, titanium and zirconium in some uraninites, and states that "these replacements of uranium are in accordance with the principle that lower valence of an element is indicative of larger ionic size, and conversely. The different 'valencies' envisaged in my classification must have influenced the nature of the replacements at the time of formation of the minerals".

A number of points made by Dr. Wasserstein in these communications call for comment.

(1) There is no ground for the supposition that radiogenic lead is produced as tetravalent ions. The generation of radium G from radium F actually brings about a superabundance of electrons for satisfying the amount needed in the electronic architecture of the lead atom.

(2) That the succeeding members of the uranium disintegration series can remain in position in the crystal lattice after the radon stage is reached is untenable, for the following reasons:

(*a*) The radius of the radon atom is 247 per cent that of tetravalent uranium. It is not possible for ions which differ more than 15 per cent in size to replace each other.

(*b*) The reaction caused by the emission of the relatively heavy α-particle at high speed is certainly big enough to cause a recoil of the parent element through such a distance that it cannot return to its original position.

(*c*) Radon is even larger than the oxygen ion. It cannot diffuse through the uraninite lattice. That it actually causes submicroscopic fractures is therefore proved by the fact that it is able to leak out of the crystal, as shown by Kulp, Bate and Broecker[4].

It must be pointed out that the lead which is finally generated within these submicroscopic fractures will not be detected by a powder X-ray diffraction investigation—it is present as isolated particles, not as a separate crystal, and not in the uraninite lattice.

(3) Even if the generation of lead within the crystal lattice were possible, the resultant shrinkage could not have been proportionate to time, but only to the amount of lead generated within the crystal lattice.

(4) It was not shown how U_3O_7 and U_4O_7 can exist in the form of a fluorite (AX_2) type of structure. How can these small unit cells which Wasserstein proposes contain the number of ions demanded by the formulæ, and Pauling's electrostatic valency principle be satisfied at the same time?

(5) Dr. Wasserstein quotes differential thermal data from a paper by Heystek and Schmidt[5] in support of a γ-type, represented by a sample from Gordonia. This curve actually shows three distinct thermal reactions, and proves that during heating a more complicated process than oxidation of $UO_{1.75}$ to UO_2 occurs.

(6) The "principle that lower valence of an element is indicative of larger ionic size, and conversely" does not exist. The following table illustrates examples where the opposite is true.

Ion	Sn^{2+}	Sn^{4-}	Pb^{2+}	Pb^{4-}	O	O^{2-}	S	S^{2-}
Valence	2	4	2	4	0	2	0	2
Ionic radius	0·93	2·15	1·20	2·15	0·60	1·40	1·04	1·85

Both the magnitude and the sign of the electrostatic charge must be taken into account to correct this statement.

(7) Dr. Wasserstein was able to arrange some of his results in such a way that older samples show smaller unit cell dimensions. This is not surprising, when the following is borne in mind: (*a*) he states that unsuitable material is neglected by means of "sample selection"[2]; (*b*) corrections are applied for the presence of thorium[1]; but the validity of the method by means of which the amount of correction is arrived at was not proved; (*c*) by means of heat treatment in different atmospheres, the unit cell dimensions of unsuitable samples are increased or decreased, and classified into three different groups[2].

(8) He tested his method once for material of unknown age, and found 850 million years for the Witwatersrand uraninite[1]; later isotopic analysis gave an age which differed from this by more than 100 per cent.

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South Africa.

[1] Wasserstein, B., *Nature*, **168**, 380 (1951).
[2] Wasserstein, B., *Nature*, **174**, 1004 (1954).
[3] Hoekstra, H. R., and Katz, J. J.; Wasserstein, B., *Nature*, **175**, 605 (1955).
[4] Kulp, J. L., Bate, G. L., and Broecker, W. S., *Amer. J. Sci.*, **252** 352 (1954).
[5] Heystek, H., and Schmidt, E. R., *Trans. Geol. Soc. S. Afr.*, **56**, 165 (1953).

Mr. S. A. Hiemstra's criticisms can be answered as follows, using his reference numbers.

(1) and (2) The direct evidence that would satisfy him may never be forthcoming; my experimental findings are the available evidence. About four hundred unit cells were measured, and several hundred other X-ray patterns furnished evidence.

The fact that lead demonstrably lowers the parameter of uraninites is evidence that tetravalent lead satisfies the requirements within the lattice in all respects—no other alternative explanation can explain the data as satisfactorily. The ideal mineralogical

material from the Belgian Congo provides evidence. Fresh crystals mined at depth are practically free from impurities. Heating in the absence of oxygen does not affect the parameter, clearly indicating that there are no effects due to weathering or radiation damage. The X-ray pattern is that of UO_2; but the parameter is less. Only its radiogenic lead-content (about 7 per cent) can be the cause for this reduction in the circumstances. (The reduction in the parameter equals the rate of 0·0035 A. per 100 million years—as has been found for other samples of different ages.)

Mr. Hiemstra suggests here and under (2*c*) that radiogenic lead occurs outside the lattice. My heating experiments were aimed at detecting such lead or its compounds, as increase of particle size and removal of strain would materially assist in detection by powder X-ray methods. It is very unlikely that such large amounts as 15 per cent—as are found in ancient uraninites—could have escaped detection not only by myself but also by so many chemists.

Radon does not enter the crystal lattice, nor does neutral lead (*cf.* RaG); but this does not mean that Pb^{4+} is therefore excluded.

I am aware of the (Wigner) recoil effect. X-ray powder diffraction by its very nature records a statistical picture: it seems reasonable to assume that lead ions will drop into vacant U-positions—a process no doubt facilitated by the order effect of heating.

(3) The measured rate of shrinkage seems sufficient comment.

(4) I have previously dealt with U_4O_7 or $UO_{1\cdot75}$ [1], and according to Zachariasen this compound has the fluorite structure. I suggested[1] that, as I am in the hands of the chemists for precision of the U : O ratios, this oxide could be written UO_{2-x}. In a further communication in *Nature*, July 23, p. 159, I write the chemistry of uraninites as $UO_{2\pm x}$, and such a concept may clear the matter in respect of the smallness of the unit cell.

The following extracts from a letter from Anderson (compare ref. 2) deals with the β-phase, which was proved to have a fluorite structure with a parameter of 5·440 A.; he writes: "A good deal of work was carried out at Harwell after . . . 1949 . . . for various reasons it has not been published . . . the oxidation of UO_2 has been proved to take place . . . there are at least three intermediate oxide phases . . . (i) the contracted cubic oxide (called by us β-phase), exactly $UO_{2\cdot25}$ (U_4O_9, with 1 additional O atom per unit cell), $a = 5{\cdot}430$ kX . . .". This may may be Jolibois's[3] $UO_{2\cdot33}$ or U_3O_7; there can be no doubt now that there is a higher oxide of the type UO_{2+x} with a fluorite structure—which is my prototype for the pitchblendes.

(5) Differential thermal analysis requires relatively large samples, and the inclusion of weathered material cannot be avoided; this affected the curve, which nevertheless indicated the essential oxidation—an unpublished curve shows this effect better.

(6) Mr. Hiemstra is guilty of some basic misconceptions in interpreting an elementary principle of crystal chemistry. In dealing with the accepted relationship between valencies and ionic radii, I was, of course, dealing with those of lead and uranium in their role as cations. He has introduced neutral and negative charges; by giving the data incompletely he is highly misleading. If he gives the data on lead more fully, we have:

Pb^{4+}	0·84 A.
Pb^{2+}	1·20
Pb	1·75
Pb^{4-}	2·15

Basically he believes that "− 4" is bigger than "+ 2"; I stand by my original statement, "... lower valence of an element is indicative of larger ionic size, and conversely"[1].

(7*a*) "Sample selection" here means that I selected the freshest portion in a specimen—there is nothing unusual in doing this. Coupling selection with the minuteness of the sample required for X-ray diffraction work, I seem to have avoided major effects of radon loss—if this is indeed a factor here (cf. Hiemstra, 2*c*)—which is more likely to be linked with weathered material.

(7*b*) The proof lies in the fact that thorianites have much higher cube-edges than uraninites, and also in the synthesis of the complete series UO_2—ThO_2, which has shown that Vegard's law applies. Such data support the validity of my method of correction for thoria, at least to a first approximation. The corrections used were sometimes small and negligible.

(7*c*) This is partly answered under (1). In practice, all samples are subjected to the same heat treatments; but owing to their different chemistry, as envisaged in my classification, they react differently. If all samples are fresh, then heating in air oxidizes the γ-types to give the requisite parameter; those that could not withstand this treatment are heated in hydrogen instead to give the required parameters. Only weathered γ-uraninite enforces a slight modification. Types can also be recognized by their origin: γ-uraninite, always with thoria, is typical of high-temperature pegmatites; α-uraninite may occur in pegmatites or high-temperature veins, and the pitchblendes occur only in hydrothermal deposits. This indicates the heating pattern.

(8) My preliminary result on the Witwatersrand uraninites obtained five years ago was at a time when I did not recognize the true nature of that type of material. In 1951 I corrected that value in a private report which I circulated to many co-workers, in which I gave a minimum value of 1,600 million years—and which, when corrected for thoria, gives more than 1,700 million years: this was a creditable effort at a time when no isotope data were available, and my own efforts were of a preliminary nature. It was this result that encouraged me to continue my work.

One may theorize a great deal about the mechanisms involved (for example, vacant U-positions ?), but I aim mainly at demonstrating that the parameters of uraninites are affected by both age and the chemistry of the mineral, that is, that there is nothing haphazard about the X-ray data; here is a neglected but powerful approach to a first-class riddle.

Since writing the above reply, I have seen a preprint of a chapter by H. R. Hoekstra and J. Katz in a new book[3]; they now accept the presence of "a βUO_2 ($UO_{2\cdot25}$)", and quote confirmatory evidence for Zachariasen's $UO_{1\cdot75}$. Further, Giletti and Kulp[4] report radon losses from uraninites to be less than 0·80 per cent.

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[1] Wasserstein, B., *Nature*, **175**, 605 (1955).
[2] Wasserstein, B., *Nature*, **174**, 1004 (1954).
[3] "The Chemistry of Uranium", National Nuclear Energy Series, Chap. 6. (Title as yet unknown.)
Giletti and Kulp, *Amer. Min.*, **40**, 481 (1955).

FORTHCOMING EVENTS

Monday, August 29—Friday, September 2

BRITISH PHARMACEUTICAL CONFERENCE, 1955 (at Aberdeen).

Wednesday, August 31—Wednesday, September 7

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at Bristol).—Annual Meeting.

Wednesday, August 31

At 8.15 p.m.—Sir Robert Robinson, O.M., F.R.S.: "Science and the Scientist" (Presidential Address).

Thursday, September 1

At 10 a.m.—Sir Alexander Todd, F.R.S.: "Nucleic Acid Structure and Function" (Presidential Address, Section B).
At 10 a.m.—Prof. F. W. Rogers Brambell, F.R.S.: "Immunity and Development" (Presidential Address, Section D).
At 10 a.m.—Dr. S. F. Dorey, F.R.S.: "The Influence of the Engineer on Sea Transport and Trade" (Presidential Address, Section G).
At 10 a.m.—Dr. D. B. Harden: "Anthropology: a Scientific Unity?" (Presidential Address, Section H).
At 10 a.m.—Prof. K. Mather, F.R.S.: "Biological Organization" (Presidential Address, Section K, K*).
At 11.45 a.m.—Mr. Alec Rodger: "The Effective Use of Manpower" (Presidential Address, Section J).
At 2.30 p.m.—Mr. P. Ritchie Calder: "The Fragmentation of Science" (Presidential Address, Section X).

Friday, September 2

At 10 a.m.—Prof. N. F. Mott, F.R.S.: "Physics of the Solid State" (Presidential Address, Section A).
At 10 a.m.—Prof. J. R. Hicks: "The Economic Foundation of Wage Policy" (Presidential Address, Section F).
At 10 a.m.—Prof. E. C. Mobbs: "Afforestation and the Community" (Chairman's Address, Section K*).
At 10 a.m.—Mr. J. F. Wolfenden: "The Educated Man in 1955" (Presidential Address, Section L).
At 10 a.m.—Mr. W. B. Mercer: "The Impact of Education on Farming" (Presidential Address, Section M).
At 11.30 a.m.—Mr. J. N. L. Baker: "Geography and its History" (Presidential Address, Section E).
At 2.30 p.m.—Mr. R. A. Hamilton: "The Scientific Work of the British North Greenland Expedition" (Special Lecture for Young People).
At 8 p.m.—Prof. C. F. Powell, F.R.S.: "Experiments at Great Heights with Free Balloons".

Saturday, September 3

At 8 p.m.—Prof. David Douglas: "The Living Past".

Sunday, September 4

At 11 a.m.—(in Bristol Cathedral)—Religious Service. Preacher: the Rt. Rev. the Lord Bishop of Bristol.
At 8 p.m.—Prof. H. D. F. Kitto: "Scientific and Dramatic Modes of Thought".

Monday, September 5

At 10 a.m.—Mr. W. N. Edwards: "Geographical Distribution of Past Floras" (Presidential Address, Section C).
At 10 a.m.—Dr. R. S. Creed: "The Sensory Pathway" (Presidential Address, Section I).
At 8 p.m.—Mr. R. J. C. Atkinson: "Stonehenge in the Light of Recent Research".

Tuesday, September 6

At 2.30 p.m.—Mr. B. J. Mason: "Man's Influence on the Weather: Recent Progress and Future Possibilities" (Special Lecture for Young People).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT IN THE DEPARTMENT OF ZOOLOGY at St. Salvator's College, St. Andrews—Joint Clerk to the University Court, College Gate, St. Andrews (August 31).

ASSISTANT STATISTICIAN (with a first- or second-class degree in statistics, or in economics combined with statistics), to act as mathematical specialist in the Statistics Section—The Secretary, North Western Gas Board, 60 Whitworth Street, Manchester 1 (September 1).

CHIEF ANALYST (with a good degree or equivalent qualifications in chemistry, and a thorough knowledge of the methods of sampling and analysis of coal and mine airs) IN THE DIVISIONAL SCIENTIFIC DEPARTMENT—The Divisional Chief Scientist, National Coal Board, Northern (N. and C.) Division, The Grange, Grange Avenue, Longbenton, Newcastle-upon-Tyne 1 (September 1).

ANALYTICAL CHEMIST (with a degree in chemistry or at least the higher national certificate in chemistry) to work mainly on plant material—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (September 3).

BIOCHEMIST, Basic grade (with a university degree in chemistry or biochemistry, or an equivalent qualification)—Prof. C. H. Gray, Department of Chemical Pathology, King's College Hospital, Denmark Hill, London, S.E.5 (September 3).

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (with a good knowledge of at least two European languages, and preferably with a degree in a scientific subject, or at least a general certificate of education in five subjects, with two scientific subjects at advanced level) IN THE COLONIAL PRODUCTS LABORATORY, London, S.W.7, for technical indexing from scientific publications—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.591/5A (September 3).

DEMONSTRATOR IN THE DEPARTMENT OF CHEMISTRY—The Registrar, King's College, Newcastle-upon-Tyne (September 5).

ASSISTANT LECTURER or LECTURER IN ANIMAL HUSBANDRY, in the Faculty of Veterinary Science—The Registrar, The University, Liverpool (September 10).

PHYSICIST (basic grade) for duty in the X-Ray Diagnostic Department—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1 (September 10).

SCIENTIFIC ASSISTANT (university graduate in science or agriculture and preferably with special training in nutrition and/or knowledge of foreign languages), for duties which include abstracting, indexing and proof reading—The Director, Commonwealth Bureau of Animal Nutrition, Rowett Research Institute, Bucksburn, Aberdeenshire (September 10).

LECTURER IN PHILOSOPHY, and a LECTURER IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING—Joint Clerk to the University Court, Queen's College, Dundee (September 15).

METALLURGIST to work in the Bio-mechanical Research Unit in the Faculty of Engineering on the metallurgical problems presented by the use of implants in surgery—The Registrar, University of London, King's College, Strand, London, W.C.2 (September 16).

LECTURER or ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Sheffield (September 17).

RESEARCH OFFICER or SENIOR RESEARCH OFFICER (with a university honours, or higher degree in science, with research experience in physical chemistry or biochemistry, and experience of the development of new chromatographic methods) IN THE DIVISION OF PLANT INDUSTRY of the Commonwealth Scientific and Industrial Research Organization, to study the properties of plant proteins with particular reference to their chromatographic separations, to collaborate in the studies of plant protein biosynthesis, and to assist with the development of chromatographic facilities and techniques in the Division—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 (September 17).

SCIENTIFIC OFFICER (with a good honours degree in botany or agricultural botany, and preferably with an interest in fruit culture) IN THE DEPARTMENT OF POMOLOGY, for work on the growth, development and cultivation of the raspberry—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee (September 17).

RESEARCH WORKER (with an honours degree in biochemistry or equivalent qualification) to assist in work on the metabolism of the autotrophic nitrifying bacteria—Prof. W. O. Kermack, Department of Biological Chemistry, Marischal College, Aberdeen (September 19).

LECTURER (with a good honours degree in chemical engineering or in physical chemistry) IN MINERAL DRESSING in the Department of Mining—The Registrar, The University, Leeds (September 23).

RESEARCH ASSISTANTS (2) (with a good honours degree in physics or physical chemistry) IN THE DEPARTMENT OF MINING—The Registrar, The University, Leeds 2 (September 23).

ASSISTANT LECTURER IN DAIRY BACTERIOLOGY—The Registrar, University College of Wales, Aberystwyth (September 30).

LECTURER IN PSYCHOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

MAY AND BAKER RESEARCH FELLOW (graduate in chemistry) to undertake research work on plant growth-regulating substances under the direction of Prof. R. L. Wain—The Registrar, Wye College (University of London), Wye, Kent (September 30).

SENIOR LECTURER IN ANTHROPOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

SENIOR LECTURER or LECTURER IN PHYSICAL CHEMISTRY or INORGANIC CHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 7).

SENIOR LECTURER and a JUNIOR LECTURER IN THE DEPARTMENT OF PHARMACOLOGY AND THERAPEUTICS at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 10).

CHAIR OF BOTANY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 15).

RESEARCH FELLOW (with experience in one of the following subjects: igneous metamorphic or structural petrology; crystallography or crystal physics; physics of high pressure; general geophysics including seismology or rock magnetism) IN THE DEPARTMENT OF GEOPHYSICS, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

SENIOR LECTURER (with an honours degree and a research degree in zoology, and teaching experience at university level) IN ZOOLOGY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 31).

ENGINEER for the design of apparatus producing very strong magnetic fields to be used in low temperature and nuclear research—"Engineer", Clarendon Laboratory, Oxford.

LECTURER (with an honours degree of a British university, and preferably some industrial and/or research experience) IN THE PHYSICS DEPARTMENT—The Principal, Paisley Technical College, Paisley.

NUCLEAR PHYSICIST (with at least a good second-class honours degree in physics, and a comprehensive knowledge of high energy physics) in the General Physics Division to lead the work of a research team using a 175 MeV. synchrocyclotron for fundamental studies in the field of high energy physics—The Establishment Officer, United

Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/383.

Senior Experimental Officer or Experimental Officer (preferably with a degree or equivalent in either physics or chemistry, with experience in the field of emission spectroscopy), for analytical and applied research work on radioactive and non-radioactive materials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. A.608/34.

Senior Geneticist, Senior Principal Scientific Officer grade (with at least a second-class honours degree in botany or other natural science, with some years experience of plant breeding and genetics), as Head of the Plant Breeding Division, West African Institute for Oil Palm Research, to plan and execute the research programme of the division, which is directed towards improving the oil-palm by selection and breeding and includes investigation of the genetics and cytology of the crop—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.197/199/08.

Senior Reader or Lecturer (preferably with experience in nutrition and food analysis) in Biochemistry—Dean Emet Said, Queen Aliyah College, Baghdad, Iraq.

Systematic Botanist (with a degree in botany or agricultural botany or equivalent qualification, and preferably with experience of systematic botany or the classification of crop varieties), for work on the classification and identification of varieties of agricultural crops; a Technical Officer (with a degree in agriculture or botany or equivalent qualifications, and preferably with field experience) for Potato Trials; and a Technical Officer (with a degree in botany or equivalent qualifications, and preferably with practical experience of seed production) for Herbage Seed Production—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

University of Reading. National Institute for Research in Dairying. Report, 1954. Pp. 140+3 plates. (Shinfield: National Institute for Research in Dairying, 1955.) 4s. [206

National Museum of Wales. Welsh Folk Museum, St. Fagans—Handbook. Pp. 29 (10 plates). (Cardiff: National Museum of Wales, 1955.) 1s. [206

Institution of Gas Engineers. Publication No. 460: 92nd Annual Report and Accounts. Pp. 41. Publication No. 461: Presidential Address by W. K. Tate, given at the 92nd Annual General Meeting, Portsmouth and Southsea, 24th to 27th May, 1955. Pp. 16. Publication No. 462: The Architect and Industry. By E. D. Jefferies Mathews. Pp. 28 (15 plates). Publication No. 463: Accelerated Continuous Carbonization: Full-scale Development and the Utilization of Low-swelling Coals. By W. Hodkinson, T. Nicklin and M. Redman. Pp. 46. Publication No. 464: Static Vertical Retorts at Southampton. By H. G. Burgess and G. Neil. Pp. 40. Publication No. 465: The "Backbone" Main in the East Midlands Area. By E. W. Pickering and J. B. Walsh. Pp. 43. Publication No. 466: Pumping of Liquids on Gas Works. By L. J. Clark. Pp. 41. Publication No. 467: Some Trends and Influences on the Domestic Load. By A. V. Horsfall. Pp. 23. Publication No. 468: A Practical Approach to the Problems of Gas Water Heating. By W. R. H. Lorimer. Pp. 11. Publication No. 469: Town Gas and the Changing Needs of Industry. By R. F. Hayman and E. A. K. Patrick. Pp. 30. Publication No. 470: Official Programme—92nd Annual General Meeting, Portsmouth and Southsea, 24th to 27th May, 1955. Pp. 11. (London: Institution of Gas Engineers, 1955.) [216

Coal-Tar Research Association. Review of Coal-Tar Technology, July–December, 1954. (Vol. 6, Part 2.) Pp. ii+95–172+xiii. (Gomersal, Nr. Leeds: Coal-Tar Research Association, 1955.) [216

Atoms for Peace Digest. Vol. 1, No. 1 (June 18, 1955). Pp. 9. (London: United States Information Service, 1955.) [216

Scottish Home Department. Freshwater and Salmon Fisheries Research Series No. 8: The Movements of Salmon Tagged in the Sea, Montrose, 1948, 1950, 1951. By K. A. Pyefinch and W. B. Woodward. Pp. 15. (Edinburgh: H.M. Stationery Office, 1955.) 3s. net. [226

Department of Scientific and Industrial Research. Report of the Mechanical Engineering Research Board, with the Report of the Director of Mechanical Engineering Research for the year 1954. Pp. iv+64+4 plates. (London: H.M. Stationery Office, 1955.) 3s. net. [236

Ministry of Fuel and Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act, 1911, for the year 1954. Northern Division. By W. Brown. Pp. ii+30+7 plates. (London: H.M. Stationery Office, 1955.) 2s. net. [236

Department of Scientific and Industrial Research. Food Investigation Special Report No. 61: Scientific and Technological Problems Involved in Using Ionizing Radiations for the Preservation of Food. By Dr. R. S. Hannan. Pp. viii+192. (London: H.M. Stationery Office, 1955.) 7s. 6d. net. [236

Lister Institute of Preventive Medicine. Report of the Governing Body, 1955. Pp. 15. (London: Lister Institute of Preventive Medicine, 1955.)

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 940, Vol. 248 (23 June 1955): On the Product of Three Homogeneous Linear Forms and Indefinite Ternary Quadratic Forms. By J. W. S. Cassels and H. P. F. Swinnerton-Dyer. Pp. 73–96. 7s. 6d. No. 941, Vol. 248 (23 June 1956): Trapped Flux in Superconductors. By A. B. Pippard. Pp. 97–129. 10s. 6d. (London: Royal Society, 1955.) [236

Wye College (University of London). Department of Hop Research Annual Report, 1954. Pp. 129. (Ashford, Kent: Wye College, 1955.) 5s. [276

Department of Scientific and Industrial Research. Report of the Forest Products Research Board, with the Report of the Director of Forest Products Research for the year 1954. Pp. vi+60+8 plates. (London: H.M. Stationery Office, 1955.) 3s. 6d. net. [276

Ministry of Agriculture, Fisheries and Food. Toxic Chemicals in Agriculture: Risks to Wild Life. (Report to the Minister of Agriculture, Fisheries and Food, and to the Secretary of State for Scotland, of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture.) Pp. iv+31. (London: H.M. Stationery Office, 1955.) 1s. 6d. net.

Other Countries

New Zealand. Department of Scientific and Industrial Research. Bulletin 113: The Academic Record of Science Students in the University of New Zealand. By I. D. Dick, R. M. Williams and Dermot Straker. Pp. 64. (Wellington: Government Printer, 1955.) 6s. 6d. [156

Folia Scientifica Africae Centralis. (Informations de l'Institute pour la Recherche Scientifique en Afrique Centrale.) T.1, No. 1 (31 Mars 1955). Pp. 24. Supplementum des *Folia Scientifica Africae Centralis.* (Travaux publies les Membres du Personnel et les Chercheurs Associes de l'I.R.S.A.C.) Pp. 14. (Bukavu: Institut pour la Recherche Scientifique en Afrique Centrale, 1955.) [156

New Zealand. Department of Scientific and Industrial Research. Geophysics Division. Bulletin E. 128: Seismological Report for April, May, June, 1952. Pp. ii+14. Bulletin E. 129: Seismological Report for July, August, September, 1952. Pp. ii+15. Seismological Observatory Bulletin, S-99: Earthquakes in New Zealand during the year 1953. By R. C. Hayes. Pp. 6+1 map. (Wellington: Government Printer, 1955.) [156

Second Annual Report of the West African Institute for Oil Palm Research, 1953–54. Pp. 99. (Benin City: West African Institute for Oil Palm Research.) 2s. 6d. [206

Rocznik Astronomiczny, Obserwatorjum Krakowskiego, 1955, Nr. 26. Supplemento Internationale. Edito per T. Banachiewicz. Pp. viii+80. (Krakow: Obserwatorjum Krakowskiego, 1955.) [206

Publications de l'Observatoire de Genève. Série M: Météorologie. Fascicule 29: Résumé météorologique de l'année 1954 pour Genève. Par Ernest Rod. Pp. 13. (Genève: Imprimerie Albert Kundig, 1955.) [206

List of Scientists in Iraq (May 1954). Pp. v+53. List of Scientists in Iran (January 1955). Pp. iii+81. (Cairo: Unesco Science Cooperation Office, 1954 and 1955.) [206

Annalen van de Sterrewacht te Leiden. Deel 18. A Catalogue of Declinations of Stars in the Zone +24° to +32°. By G. Van Herk. Pp. 52. (Leiden: Staatsdrukkerij- en Uitgeverijbedrijf, 1955.) [206

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 34, No. 31: A New Species of Thrush from Angola. By Austin L. Rand. Pp. 327–330. (Chicago: Chicago Natural History Museum, 1955.) 10 cents. [206

Bulletin of the American Museum of Natural History. Vol. 106, Article 4: The North American Bolas Spiders of the Genera *Mastophora* and *Agatostichus*. By Willis J. Gertsch. Pp. 221–254+plates 3–6. (New York: American Museum of Natural History, 1955.) 75 cents. [206

Geology, Mineral Deposits and Prospects of Mining Development in the British Solomon Islands Protectorate. By John C. Grover. (The Interim Geological Survey of the British Solomon Islands—Memoir No. 1.) Pp. ix+108 (41 plates). (Honiara, British Solomon Islands Protectorate: Western Pacific High Commission; London: Crown Agents for Oversea Governments and Administrations, 1955.) 30s. [206

Occupational Medical Foundation and Institute of Occupational Health. Annual Report, 1954. Pp. 47. (Helsinki: Occupational Medical Foundation and Institute of Occupational Health, 1955.) [236

Malayan Grading Rules for Sawn Hardwood Timber, 1955 edition. Pp. 54. (Singapore: Government Publications Bureau, 1955.) [236

Canada: Department of Agriculture. Annual Report of the Forest Insect and Disease Survey, 1954. Pp. 135. (Ottawa: Queen's Printer, 1955.) [236

Israel Scientific Press. (Research Council of Israel—Ministry of Education and Culture—Hebrew University of Jerusalem—Weizmann Institute of Science—Bialik Foundation.) Report, May 1955. Pp. 16+x. Israel Science Bibliography: a Guide to Books, Dissertations and Periodicals published in Israel. Vol. 1, No. 1 (January–June 1954). Pp. 37. (Jerusalem: Israel Scientific Press, 1954 and 1955.) [236

Fisheries Research Board of Canada. Bulletin No. 102: Survey of Bar Clam Resources of the Maritime Provinces. By J. C. Medcof and J. S. MacPhail. Pp. vi+6. (Ottawa: Fisheries Research Board of Canada, 1955.) [236

Tanganyika: Geological Survey Department. Report No. 1: The Tunduru–Ruvuma Area of the Southern Province: a Reconnaissance of the Geology, Soils, Vegetation and Hydro-electric Potential. By Dr. D. R. Grantham. Pp. iii+14+1 map. (Dar-es-Salaam: Government Printer, 1955.) 3s. [276

Northern Rhodesia. Water Development and Irrigation Department. Annual Report for the year 1954. Pp. 10. (Lusaka: Government Printer, 1955.) 1s. [276

Inter-American Tropical Tuna Commission Bulletin. Vol. 1, No. 3: Algunos Aspectos de la Dinamica de las Poblaciones u su Importancia para la Administracion de Pesquerias Marinas Commerciales. Por Milner B. Schaefer. Pp. 57–88. Vol. 1, No. 4: Morphometric Comparison of Yellowfin Tuna from Southeast Polynesia, Central America, and Hawaii. By Milner B. Schaefer. Pp. 89–136. (La Jolla, Calif.: Inter-American Tropical Tuna Commission, 1955.) [276

Transactions of the American Philosophical Society. New Series. Vol. 45, Part 3: Songs of the Nootka Indians of Western Vancouver Island. By Helen H. Roberts and Morris Swadesh. Based on Phonographic Records, Linguistic and other Field Notes made by Edward Sapir. Pp. iii+199–328. (Philadelphia: American Philosophical Society, 1955.) 2 dollars. [276